CHEMICAL CONTROL OF RANGE WEEDS

U.S. DEPARTMENT OF AGRICULTURE
U.S. DEPARTMENT OF THE INTERIOR

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CHEMICAL PLANT CONTROL SUBCOMMITTEE
RANGE SEEDING EQUIPMENT COMMITTEE

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PREFACE

This handbook is intended as an aid to agricultural workers and is a revised edition of that published in 1959. The number of plants included has been increased to 49, with new material for 5 species not included in the earlier report. The weedy range plants were selected for their widespread occurrence and importance and for feasibility of control by use of chemicals. A few are also important on cropland. Some of the plants have value as forage or browse under certain conditions.

The purpose of this handbook is to provide suggestions on the control of range weeds with chemicals. The rancher or range manager will need to decide which plants are undesirable on a particular range and whether they should be controlled. Rangeland should not be permitted to become a reservoir for perpetuating weeds. Chemical control procedures as determined from published literature, field experience, and personal correspondence are reported here. Before using any herbicide in this handbook, check to see if it has been registered for use on grazing land. Information about many herbicides is included only to show those that are promising in research. Some may never be registered for use on grazing areas. Registered uses are shown on the labels on herbicide containers, in company brochures, and in USDA Summary of Registered Agricultural Pesticide Chemical Uses provided by the Pesticide Regulation Division, Agricultural Research Service, U.S. Department of Agriculture.

An attempt has been made to cite the source or give references for all information presented. Personnel desiring to refer publicly to data or statements in this handbook should consult the individuals who performed the original research.

The Chemical Plant Control Subcommittee of the Range Seeding Equipment Committee that revised this handbook is the same that prepared the earlier reports, but some members have changed because of transfers or reassignments. An effort has been made to maintain continuity of membership and to include members from all agencies and institutions involved with weed control on rangelands.

The subcommittee is composed of the following membership:

Donald R. Cornelius, Chairman, Agricultural Research Service, Berkeley, Calif.
Lowell K. Halls, U.S. Forest Service, New Orleans, La.
Arnold Herrwagon, Soil Conservation Service, Lincoln, Nebr.
Donald F. Hervey, Colorado State University, Fort Collins, Colo.
Donald N. Hyder, Agricultural Research Service, Ft. Collins, Colo.
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W. C. Robocker, Agricultural Research Service, Pullman, Wash.
Fred H. Tschirley, Agricultural Research Service, Tucson, Ariz.

Dr. Dayton Klingman, Leader, Weed Investigations-Grazing Lands, Crops Research Division, ARS, reviewed the manuscript, and his suggestions have been incorporated.

Caution: Chemicals are dangerous. Use only as directed and heed all precautions on the container label. Check the registration numbers and verify that the directions for use include the target weeds to be controlled. Drift from aerial spraying can contaminate nearby crops and forage, lakes, and reservoirs. Improper use and careless disposal of unused portions can lead to poisoning of humans, domestic animals, desirable plants, pollinating insects, fish, and wildlife, and can contaminate water supplies.

CONTENTS

CHEMICAL NAMES AND ABBREVIATIONS[1]

2-(2,4-DP)	See dichloroprop
2,3,6-TBA	2,3,6-trichlorobenzoic acid
2,4-D	2,4-dichlorophenoxyacetic acid
2,4,5-T	2,4,5-trichlorophenoxyacetic
ae/A or ae/ac	acid equivalent per acre
aehg or ahg	acid equivalent per hundred gallons
ai/A or ai/ac	active ingredients per acre
amitrole[2]	3-amino-1,2,4-triazole
ammate-AMS	ammonium sulfamate
arsenite	sodium arsenite
atrazine	2-chloro-4,ethylamino-6,isopropylamino-s-triazine
borate	sodium borate complex
borate-2,3,6-TBA	mixture of borate and 2,3,6-TBA
brush-killer	mixture of 2,4-D and 2,4,5-T
CIPC	isopropyl N-(3-chlorophenyl) carbamate
cm	centimeter
dalapon	2,2-dichloropropionic acid
diallate	2,3-Dichloroallyl diisopropylthiolcarbamate
dicamba	2-methoxy-3,6-dichlorobenzoic acid
dichlorprop	2-2,4-DP) or alpha-(2,4-dichlorophenoxy) propionic acid
dinitro	DNAP, DNBP, DNC
DNAP	4,6-dinitro-o-sec-amylphenol
DNBP	4,6-dinitro-o-secondary amylphenol
DNC	3,5-dinitro o cresol
EPTC	ethyl-di-n-propylthiolcarbamate
erbon	2-(2,4,5-trichlorophenoxy)ethyl-2,2-dichloropropionate
fenac	2,3,6-trichlorophenylacetic acid
fenuron	3-phenyl-1,1-dimethylurea
ft	foot
gal/A or gpa	gallons per acre
IPC	isopropyl N-phenylcarbamate
lb	pound
lb/A	pounds per acre
lb a/A	pounds active ingredient per acre
MCPA	2-methyl-4-chlorophenoxyacetic acid
monuron	3-(p-chlorophenyl)-1, 1-dimethylurea
paraquat	1:1'-dimethyl-4,4'-dipyridylium di-(methyl sulfate)
PBA[3]	polychlorobenzoic acids
picloram	4-amino-3,5,6-trichloropicolinic acid
propazine	2-chloro-4,6-bis (isopropylamino)-s-triazine
psi	pounds per square inch
qt	quart
silvex	2-(2,4,5-trichlorophenoxy) propionic acid
simazine	2-chloro-4,6-bis(ethylamino)-s-triazine
TBA	trichlorobenzoic acid
tbsp	tablespoon
TCA	trichloroacedic acid
WSA	Weed Society of America
SWC	Southern Weed Conference
NWCC	Northern Weed Control Conference
NCWCC	North Central Weed Control Conference
WWCC	Western Weed Control Conference

[1] The chemical names and abbreviations used in this handbook follow the report on nomenclature by the Terminology Committee of the Weed Society of America published in *Weeds*, vol. 13, No. 2, April 1965.

[2] Amitrole is now the preferred common name for a chemical formerly designated in some reports as ATA, amizol, or amino triazol.

[3] Usually available as mixed isomers.

GRASSES

DOWNY BROME (Bromus tectorum L.)

Description and Occurrence

Downy brome, also known as cheatgrass, downy chess, broncograss, and junegrass, is an annual weedy grass that has become widely established on western ranges, especially in the big sagebrush type, since its introduction from Europe. Pure stands of downy brome produce more forage for livestock than does depleted sagebrush range. However, downy brome is less desirable than perennial grasses because of its short, green feed period, slow growth in the spring, great variability in yield from year to year, and high fire hazard.

Control and Revegetation

Control of downy brome and seeding of perennial grasses has not been undertaken on rangelands to an appreciable extent primarily because of lack of methods. Millions of acres of downy brome range are adapted to perennial grasses; however, many studies and much practical experience have shown that successful seeding into downy brome-infested areas requires adequate weed control in the seeding year (*10, 13*).

Conventional methods of disking and seeding in the spring, or late in the fall in years when downy brome emerges before winter, usually offer adequate seedbed preparation but may provide weed control of varying success, depending upon timing and thoroughness of the operation. Techniques using herbicides have been and are being studied in an attempt to provide more efficient and reliable weed control and seedbed preparation for establishing perennial grasses on downy brome-infested lands. Also, chemical weed control may extend the practicability of seeding to areas not suitable for plowing because of rough terrain or rocky soils.

A nontillage method of seeding perennial grasses using paraquat for downy brome control in Nevada and California has shown promise (*7*). Paraquat at ½ to 1 lb./a. plus a surfactant has controlled downy brome satisfactorily. It is completely adsorbed and deactivated upon contact with the soil so that perennial grasses can be seeded immediately after spraying. Low volatile esters of 2,4-D at ½ lb./a., when added to paraquat, have controlled broadleaf weeds that usually accompany downy brome. In most areas of Nevada and northeastern California, and in most years, paraquat spraying and seeding is confined to spring; consequently, this method faces limitations similar to those of other spring-seeding techniques.

Applying soil-active herbicides during one fall and seeding the area to perennial grasses in the next fall (chemical-fallow) has been indicated as another approach to establishment of perennial grasses in downy brome-infested areas (*6, 8, 12*). Atrazine at 1 lb./a. has shown most promise in these techniques. With chemical fallow, another weed control measure might be necessary the seeding year to insure establishment of seeded grasses.

Applying soil-active herbicides in the fall and seeding the next spring was also examined in northeastern California (*1*). Atrazine and simazine at 1 and 2 lb./a. controlled downy brome best, with better establishment of pubescent wheatgrass with simazine.

Herbicides have also been used experimentally to control downy brome in established stands of perennial grasses. In Washington (*4*), downy brome was controlled up to 98 percent in established stands of intermediate wheatgrass with IPC at 4 and 8 lb./a. without injury to perennial grass. CIPC at 4 to 8 lb./a. gave less consistent control, but also was not injurious to the perennial grass.

Studies of downy brome control on other than rangelands indicate a wide range of effective herbicides. Downy brome control in winter wheat and cereals has been studied in eastern Washington, Oregon, and Wyoming (*1, 2, 3, 5, 9, 14*). In these studies good control was achieved with atrazine, simazine, propazine, amitrole, atrazine + amitrole, diallate, and IPC.

At present, chemical control of downy brome on rangelands is experimental. Also, *none of the herbicides mentioned are registered for range use.*

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Raymond A. Evans

FOXTAIL BARLEY (Hordeum jubatum L.)

Description and Distribution

Foxtail barley is an introduced, short-lived perennial grass which now infests all except the Southern States east of the Mississippi River. It ranges as far north as Alaska and south to Mexico. It is a coarse grass with a bunch habit of growth and grows from 6 to 24 inches in height. The heads consist of numerous one-seeded spikelets with two associated rudimentary spikelets, all of which are awned. It is commonly found in low wet spots of meadows and irrigated fields, on the edges of ponds, streams, and irrigation ditches, and in swampy, alkaline flats. It begins growth early in the spring and is often headed when forage crops are ready for cutting. The large number of barbed awns can cause injury and even death to livestock, particularly sheep, that consume hay of which it is a part (*3*).

Chemicals

In a series of tests (*1*), IPC, CIPC, and TCA showed no promise for controlling foxtail barley. The sodium salt of dalapon appeared to be the only effective chemical of those tried.

Rate of Application, Volume, and Carrier

Forty-eight lb./a. of dalapon in water at 50 g.p.a. gave complete kills (*1*). Lower rates of 16 and 32 lb./a. allowed some survival. A combination of 30 lb./a. of dalapon and 4 lb./a. of amitrole also gave a satisfactory kill. Heavy grazing accompanying the treatments was also found to add to the effectiveness of chemical treatment.

Time of Application

Applications were made in both May and July. Complete kills were obtained in both months of treatment, although the earlier month is recommended because of the early growth habit of foxtail barley.

General Considerations

Treatments with dalapon also kill most of the desirable forage grasses in the treated area. Establishment of a suitable forage species such as tall wheatgrass or tall fescue, together with proper fertilizer application, may be a practical method of converting high water table areas from foxtail barley into profitable pasture (*2*). From the preliminary work it appears that a combination of cultural, management, and chemical treatments may prove to be the most economical method of controlling foxtail barley.

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W. C. Robocker

MEDUSAHEAD (Elymus caput-medusae L.)[1]

Description and Occurrence

Medusahead, a winter annual introduced grass, is one of the primary range weed problems in Oregon, Idaho, California, and Washington. A small infestation has recently been located in western Nevada. Medusahead is a serious threat to the range-livestock industry because of its aggressiveness in competition with other annuals, such as downy bromegrass (*Bromus tectorum* L.), and the low preference of cattle and sheep for the grass.

Control and Revegetation

Some possibilities for the use of herbicides in medusahead control are: (1) Concurrent application of contact herbicides and seeding of perennial grass species, (2) preemergence application of soil-active materials preparatory to seeding replacement species, (3) selective removal of medusahead from native perennial or seeded perennial grass stands, (4) selective removal of medusahead from other annual grasses, and (5) eradication of small patches of medusahead.

Several herbicides show promise for use in medusahead control, but none is registered at this time for range use.

Paraquat at 0.5 lb./a. has shown much promise as a postemergence herbicide applied during seeding (*2*) and for selective removal of weedy annual grass from seedings of rose clover (*Trifolium hirtum* All.) and subclover (*T. subterraneum* L.) in California, but has been less satisfactory in Oregon, Washington, Idaho and Nevada. The rapid adsorption and deactivation of paraquat when it makes contact with the soil enables seeding of perennial grasses immediately after herbicide application.

Delapon has given excellent control of medusahead when applied during the vegatative stage. Three lb./a. applied 30 days after emergence gave 100 percent kill in test under California annual range conditions, while 2 lb./a. gave 96 percent control (*3*). Results from eastern Oregon (*7*) and Idaho (*6*) indicate that 2 lb./a. of dalapon gives adequate medusahead control. Medusahead is more susceptible to dalapon than is downy brome and possibly can be removed recurrently from downy brome sites too rough for seeding perennial species. Dalapon has a rather short residual activity, but several weeks must elapse after application before perennial grass species can be planted.

Simazine and EPTC aided in the establishment of rose clover and hardinggrass (*Phalaris tuberosa* L. var. *stenoptera* (Hack.) Hitch) on the California annual range by reducing competition from resident annual plants, primarily medusahead (*4*). The herbicides were applied to burned medusahead stubble late in September and to the hardinggrass and clover drilled in mid-October, or as soon as sufficient rain had fallen to move the herbicide into the soil.

Atrazine at the rate of 1 lb./a. of active ingredient has reduced medusahead infestations in established crested wheatgrass (*Agropyron desertorum* (Fisch.) Schult.) stands (*7*).

Experimental results from Oregon indicate that selective herbicides suitable for speeding natural recovery of partially deteriorated native ranges infested with medusahead have not been found (*7*).

Amitrole at ½ to 4 lb./a. sprayed on annual grassland infested with medusahead, when the medusahead was in the boot or soft dough stage, reduced viable caryopses from 60 to 100 percent, and seed production the following year from 75 to almost 100 percent (*1*).

Killing medusahead is only the first step toward control. The void left in the plant community by control of the weed species must be filled by desirable species or reinfestation will occur.

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Claire E. Letson

[1] The scientific name of the species of medusahead found in the United States has been widely accepted as *Elymus caput-medusae* L. There is evidence that the valid name for the American introduction is *Taeniatherum asperum* (Simonkai) Nevski.

FORBS

BITTERWEED

(Hymenoxys odorata DC.)

Description and Occurrence

Bitterweed is a much-branched annual composite, from a few inches to 2 feet tall. Each ascending stem terminates in a head of many small, yellow flowers. Normally each head produces from 25 to 75 seeds. Under favorable conditions growth may begin in December, but most growth is from early spring to early or midsummer. The plant has a bitter taste, and the leaves give off an aroma when crushed (*1*).

Bitterweed is widely distributed in Texas and extends from California to Kansas and south to Mexico. It is most common along flooded sites, drainageways, lakebeds, and roadways, and in overgrazed pastures and ranges.

Chemicals for Control

A low-volatile ester of 2,4-D is very effective.

Rate, Volume, and Carrier

Spray with 1 lb./a. acid equivalent in 4 g.p.a. or more of water from aircraft or in 15 g.p.a. of water with ground equipment (*2*).

Time of Application

The prebloom or early flowering stage is best. Spraying when in flower may result in a good kill, but does not materially reduce seed production. Susceptibility is greatest when soil moisture is plentiful. Adding diesel oil to the spray mixture may extend the effectiveness of treatment to drier or less optimum growth conditions.

General Considerations

Animals poisoned.—In general, sheep are readily poisoned by eating large amounts of bitterweed, and cattle have died in heavily infested areas. Sheep poisoning by bitterweed has been very common in the Edwards Plateau region of Texas in winter and early spring before green forage was available.

Poisonous nature and symptoms.—Bitterweed is most toxic during drought years. About 1 lb. of green, immature bitterweed will kill a sheep if eaten during a 2-day period.

The most common symptoms of bitterweed poisoning are loss of appetite, cessation of rumination, depression, indications of abdominal pain, bloating, and green regurgitated material about the mouth and nose. Postmortem observations will show congestions of the lungs as well as other internal disturbances.

Control and management.—There is no medical cure for severe poisoning. When animals show the symptoms, they should be removed to desirable pastures or put on feed.

For long lasting control of bitterweed, spray application of 2,4-D should be followed by good range management practices, including proper season, rates, and distribution of grazing.

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Lowell K. Halls

DEATHCAMAS (Zygadenus venenosus S. Wats; Z. paniculatus [Nutt.] Wats; Z. elegans Pursh.)

Distribution and Description

Deathcamases are herbaceous perennials of the lily family that are sometimes confused with the edible camases (*Quamasia* spp.). Approximately 15 species are found in North America. Their distributions cover most of the continent and their adaptations include dry and moist sites from near sea level to 12,000 feet elevation. Grassy deathcamas (*Z. gramineus*), meadow deathcamas (*Z. venenosus*), foothill deathcamas (*Z. paniculatus*), and mountain deathcamas (*Z. elegans*) are the most common species in the West. Grassy and meadow deathcamases are the most dangerous. The majority of sheep losses from poisonous plants on spring ranges have been attributed to deathcamases, which are green and succulent at an early time. The plants are glabrous with long, narrow leaves arising from a deeply placed bulb. Leafy or leafless stems vary in height from a few inches to 4 feet. The flowers are greenish white or yellowish in color.

Chemicals

Deathcamas is very susceptible to 2,4-D in ester formulations, but is moderately tolerant of 2,4,5-T.

Rate, Volume, and Carrier

Apply 2,4-D ester at 1.5 lb./a. in any suitable carrier (water plus wetting agent, oil-water emulsions, or straight diesel oil) at a total spray volume as low as 5 g.p.a. The time of spraying is more critical than rate, volume, and carrier.

Time of Application

Spray when the plants have three to six leaves and before the appearance of flower buds. Mean kills of 90 to 100 percent can be expected. Effectiveness drops very rapidly after the appearance of flower buds and where shrubs can intercept the spray.

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D. N. Hyder

WESTERN FALSE-HELLEBORE (*Veratrum californicum* Durand)

Description and Occurrence

Western false-hellebore occurs on mountain meadows of the 11 Western States. Low palatability and competition with more valuable forage plants on soils potentially high in production make this plant undesirable on rangeland. It contains a poisonous property, but livestock are seldom poisoned under normal grazing conditions. The plants are strong perennials, 3 to 8 feet in height, with a short, thick rootstock.

Chemicals for Control

The ester form of 2,4-D has been effective in controlling western false-hellebore (*1,2*). Diesel oil has also been used as a contact herbicide to eradicate this weed (*4*).

Rate, Volume, and Carrier

Butoxyethanol ester of 2,4-D at 2.6 lb. acid equivalent in 160 gallons of water per acre gave 93 percent kill of plants in California (*1*).

The herbicidal properties of 2,4-D (isophopyl and butyl esters mixed) and amitrol were compared for control of western false-hellebore in Oregon (*2*). A rate of 3 lb./a. of active ingredient of each herbicide was sprayed in water at 50 gal./a. with a boom spray at 50 p.s.i. The control with 2,4-D was 95 percent and with amitrol 65 percent.

A test using 4 lb. acid equivalent of isopropyl ester of 2,4-D per acre and retreatment at same rate 1 year later gave excellent control in Washington. The density of false-hellebore was only 6 percent of the density before spraying (*3*). All these tests may be considered preliminary to development of recommendations for general use. The results are encouraging, but more experimental work with chemicals is needed. Results indicate some followup retreatment will be necessary for complete control. This retreatment may be with hand sprayer on small scattered spots that escape and survive.

Diesel oil having 27 A.P.I. gravity satisfactorily controlled western false-hellebore as an individual plant treatment (*4*). Lighter diesel oil up to 32 A.P.I. gravity killed the plants but was less effective than the heavier oil. A regular oil can or a pressure sprayer of the backpack type with nozzle removed to give a small stream was used to pour the diesel oil into the funnel-like collars of the leaves. One gallon of diesel oil treated about 320 plants. Approximately 1,000 plants were treated per man-hour.

Time of Application

Spray with selective herbicides should be applied after most of the leaves are expanded but before bloom appears. In California this stage occurs about mid-June. The diesel oil treatment was most satisfactory when applied at the time the plants began to bloom. Earlier application was not so successful because young plants were too small and difficult to find.

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Donald R. Cornelius

HALOGETON (Halogeton glomeratus [M. Bieb.] C. A. Mey.)

Description and Distribution

Probably no range weed has received such widespread attention as halogeton following discovery of its poisonous properties. There has been much work on chemical control of this plant, but no entirely satisfactory agent has been discovered. This has been largely due to:

1. The prolific production of easily disseminated winged, black seeds, having a short period of dormancy and high germination.
2. Germination from early spring through midsummer under favorable conditions.
3. A rapidly developing resistance to chemicals with maturation of the plant.
4. The pronounced dormancy of the wingless, brown seed, with longevity of 5 or more years under favorable conditions (*5*).

Halogeton infests an area of over 20 million acres in Nevada, Utah, Idaho, Montana, Wyoming, Colorado, California, and Oregon (*1*). The area of infestation appears to be increasing, particularly on denuded and depleted ranges.

Chemicals

The low-volatile esters of 2,4-D, such as propylene glycol butyl ether ester or butoxyethanol ester, should be used for early postemergence treatment. For late postemergence sprays and retreatment of earlier sprays, 2,4-D fortified with DNBP should be used (*2*). For sterilization of small spot areas of infestation, borate-chlorate mixtures, monuron, or 2,3,6-TBA may be used. Don't graze for 1 year after use of 2,3,6-TBA and DNBP.

Rate of Application, Volume, and Carrier

2,4-D should be applied at 2 lb./a. in 15 to 20 gallons of water per acre (*2, 3*). For later application, 2,4-D at 4 lb./a. plus 1 quart of DNBP in 15 gallons of diesel oil per acre should be applied. Borate-chlorate mixtures are applied at 8 lb. per square rod; monuron at ¼ lb. per square rod, and 2,3,6-TBA at ⅛ lb. per square rod (*2*).

Time of Application

Early applications of 2,4-D should be made in June, at the preflowering stage of growth. By July 10 the plants are becoming increasingly resistant to 2,4-D, and after that date the mixture of 2,4-D and DNBP in oil should be used in both initial and second applications. Retreatment of plants not killed by an earlier application should be made before seed is produced. Soil sterilants are preferably applied in late fall or early spring.

General Considerations

The successful eradication of halogeton with chemicals depends on the development of the plant, concentration and coverage of herbicide, and followup treatments to prevent maturation of late germinating or partially killed plants. Spray applied to kill halogeton also will kill other broadleaf vegetation, and indiscriminate use will only add to the density and spread of the weed in many cases. Long-term control of halogeton depends upon restoration and vigor of range vegetation, preferably with those plants which are useful as forage.

Halogeton control with presently recommended chemicals is comparatively expensive and should be restricted mainly to iolated spot infestations where complete kills and resultant eradication are possible. Aerial application of 2,4-D is not a feasible method of obtaining satisfactory control (*4*).

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W. C. Robocker

HOARY CRESS (Cardaria draba Desv.)

Distribution and Description

Hoary cress, also referred to in some areas as whitetop or perennial peppergrass, is a member of the mustard family, Cruciferae. This native of Central Europe and Western Asia, sometimes referred to under its old name of *Lepidium draba*, was first noted in the United States about 1889 near seaports of New York, Washington, and elsewhere. Almost simultaneously it was found in alfalfa-growing regions of the Southwest, indicating introduction with imported grass seed. It is now found throughout North America as a common noxious weed on cultivated lands, along roadsides and other rights-of-way.

Hoary cress is characterized by its corymblike inflorescence, mustardlike taste, and its glabrous, two-valved fruit (seed pod). Leaves of the upper stem of this erect perennial, 8 to 20 inches tall, are sessile, strongly clasping the stem with earlike lobes. This deep-rooted plant is early growing and maturing; however, the leaves will remain green until frost.

Chemical

2,4-D amines.	Sodium chlorate..	5 to 10 lb/ square rod
	Borate-chlorate mixtures.	10 to 20 lb/ square rod
	Concentrated boron.	15 to 25 lb/ square rod

Rate, Volume, and Carrier

On nonagricultural crop areas 2 lb. acid equivalent 2,4-D when hoary cress is in bud stage and again in the fall will control it if treatment is repeated for 2 or 3 years. In cropped areas treatment should be made when small grains are in stage recommended for control of annual weeds, but always before the hoary cress reaches the bloom stage.

The other herbicides listed are soil sterilants which can be used to eliminate hoary cress, provided 3 to 5 years sterilization can be tolerated. Best results are usually obtained from fall treatment, using the rates indicated per square rod.

Time of Application

This plant starts growth early in the spring. Treatments after the bloom stage with 2,4-D are ineffective. Best results will be obtained during the early spring bud stage and the late fall rosette stage of growth.

RUSSIAN KNAPWEED (Centaurea picris Pall. [C. repens L.])

Distribution and Description

Russian knapweed, first reported in California between 1910 and 1914, is thought to have been introduced from the Caspian region of southern Russia as an impurity in Turkistan alfalfa seed. It is a serious pest in Turkestan, South Africa, Australia, and is common on both irrigated and dry farmlands west of the Missouri River in the United States.

This perennial has a vigorous, spreading root system, often extending to a depth of 2 to 4 feet. The stem is erect, branches at the base, and has dense gray pubescence or hairlike covering. Upper leaves are small, linear, with unbroken edges; stem leaves are intermediate in size with slightly toothed margins; basal leaves are large, grayish green, and deep notched. Its black, heavily scaled roots are a notable characteristic (5).

Chemical

The amine form of 2,4-D is most often recommended for spraying. The currently recommended soil sterilants include sodium chlorate, chlorate-borate mixtures, and benzoic acids.

Rate, Volume, and Carrier

Russian knapweed is tolerant to light dosages of 2,4-D. For good control, apply 4 to 6 lb./a. of 2,4-D amine before bud stage and again to fall regrowth. To eliminate 90 percent or more of an established stand, use 40 to 80 lb. of 2,4-D amine per acre. Spot-treat regrowth with 2 pounds of the ester or amine per acre (5).

Treatments with soil sterilants in eastern Fresno County, Calif., where soil is light textured and annual rainfall is from 12 to 16 inches, were 95 percent effective (3). Rates of application per square rod for different chemicals are as follows: sodium chlorate, 3 lb.; and chlorate-borate mixture 8 lb. In the 4- to 7-inch rainfall belt of western Fresno County where soils are heavy textured, sufficient penetration cannot be obtained. Here, recommended treatment is 10 lb. sodium chlorate per square rod, followed by flooding

with 10 to 12 inches of water. Roadside treatment is 16 lb. chlorate-borate mixture per square rod (*3*).

2,3,6-TBA should be used. Apply at 10–20 lb./a. when the knapweed has 6 weeks growth or has reached the early bud stage. This rate has eliminated 95 to 100 percent of the weed where used in Wyoming. 2,3,6-TBA-boron mixture, as a granular formulation with 8 percent 2,3,6-trichlorobenzoic acid, may also be used at the rate of 1½ lb. per square rod, applied either in spring or fall.

Where 3–5 years of soil sterilization can be tolerated, the following chemicals may be used at the specific rates in lb. per square rod:

	Pounds
Sodium chlorate	5–10
Chlorate-borate mixtures	10–20
Concentrated boron	15–25

Time of Application

Spraying with 2,4-D is most effective when applied at the early bud stage, with a second application made to the regrowth. 2,3,6-TBA should be applied at the same time. The first treatment with soil sterilants tested in Fresno County, Calif., are applied in December, and second treatments are made in February (*3*). A borate-2,3,6-TBA mixture may be applied in either spring or fall. The treatments recommended for 3–5 year sterilization are usually more effective when applied in the fall.

General Considerations

Delay grazing for 1 year after treatment with 2,3,6-TBA. Great care should be taken in obtaining clean seed, since Russian knapweed is especially well adapted for spread by this method, being about the same size as alfalfa seed. Some grasses may be completely removed by soil sterilants; however, bluegrass, alkali sacaton, and other grasses are quite resistant to 2,3,6-TBA. PLEASE NOTE: The borate compounds are safe from fire, but sodium chlorate is an active oxidizing agent and may create a fire hazard.

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Claire E. Letson

LOW LARKSPURS (Delphinium megacarpum Nels. & Macbr.; D. nelsonii Greene; D. menziesii DC.; D. bicolor Nutt.)

Distribution and Description

The low larkspurs are perennial herbs of the buttercup family (*Ranunculaceae*) with stems usually less than 20 inches tall arising from single or clustered tubers. The leaves are palmate, inflorescences are few-flowered racemes, and the flowers usually are blue or purple although most species have white-flowered forms. Low larkspurs are common on the plains and sagebrush ranges of the Western States. They are poisonous and often kill cattle in the spring. Recommendations for chemical control apply most specifically to sagebrush larkspur (*D. megacarpum*).

Chemicals

Ester forms of 2,4-D at 1 lb./a. are more effective than 2,4,5-T at 2 lb./a.

Rate, Volume, and Carrier

Apply 2,4-D ester at 1 to 1½ lb./a. in water plus wetting agent (or other carriers if preferred) at a total spray volume as low as 3 gal./a. The rates recommended for big sagebrush should be used if simultaneous sagebrush control is desired. Plan the timing of application carefully.

Time of Application

Spray when low larkspur is vegetative, not later than when flower stems are 2 inches high. With correct timing, kills of 90 percent can be expected with 2,4-D at 1 lb./a. Plants not killed have been protected from the spray by sagebrush crowns.

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D. N. Hyder

LOCO (Astragalus sp. and Oxytropis sp.)

Description and Occurrence

Loco is a general term applied to certain plants of the pea family. They have compound leaves and grow in tufts with a large taproot. It occurs throughout the western arid and semiarid States.

Chemicals for Control

Apparently, under favorable conditions, most of the important species can be controlled satisfactorily with the ester form of 2,4-D. 2,4,5-T is not as effective as 2,4-D on loco.

Rate, Volume, and Carrier

Two lb./a. of an ester of 2,4-D in water or oil.

Time of Application

Spray when the plants are in bloom. Much better kills are obtained when there is abundant soil moisture.

General Considerations

Loco has long been a problem on range, especially where early spring feed for livestock is lacking and it is necessary to turn livestock on range. In dry years, it is often one of the first plants to "green up."

Not all loco weeds are poisonous. Some of the poisonous species are white point or silvery loco (*Oxytropis sericea* Nutt.), Lambert crazyweed (*O. lamberti* Pursh.), spike crazyweed (*O. macouni Greene*), Rocky Mountain crazyweed (*O. saximontana* Nels.), timber poisonvetch (*Astragalus convallarius* Greene), blue or specklepod loco (*A. lentiginosus* Dougl.) and wooly loco (*A. mollissimus* Torr.). Two grooved poisonvetch (*Astragalus bisulcatus*/Hook/Gray) is a selenium-bearing plant capable of poisoning livestock.

The many different kinds of loco in the West make loco control on range a bit complicated. Different species give different results to treatments.

In parts of the West, 3 lb. of 2,4-D ester obtained nearly a 70-percent kill. There was some additional benefit due to kill of other unpalatable plants, such as fringed sagewort and phlox. Grass production was definitely increased.

White point loco is the most difficult to kill. Closely related plants of this species in other areas respond well to treatment.

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Karl G. Parker

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James A. Young

LUPINE (Lupinus spp.)

Description and Occurrence

Lupines are annual, biennial, or perennial herbs. They are members of the pea family. Flowers are in spike-like, terminal racemes and are blue, pink, yellow, or white. Leaves are palmately compound with 3 to 17 leaflets. Lupines are of most importance in foothill and mountain rangelands. Seldom are infestations heavy enough in plains areas to require control.

Chemicals

Lupines are generally sensitive to the esters of 2,4-D.

Rate, Volume, and Carrier

An ester of 2,4-D should be applied at 2 lb./a. in 3 g.p.a. of oil or 10 g.p.a. of water (3, 4, 5). Less than 10 g.p.a. of water can be used if coverage is uniform.

Time of Application

2,4-D applied after plants have reached a height of 5 inches and before full bloom will result in a kill of about 80 percent the first year. Growing conditions directly affect the efficiency of spray applications, with best results occurring when moisture and temperature permit rapid growth of plants.

General Considerations

Some lupines are not poisonous. However, any lupine species should be suspected unless it is known to be nonpoisonous or of low toxicity. *Lupinus sericeus, L. leucophyllus, L. argenteus, L. caudatus,* and *L. perennis* are listed as the most poisonous species (*1*). *L. albus, L. angustifolius,* and *L. leucopsis* are also listed as toxic (*2*). Plants are poisonous at all times during the growing period. All of the aerial parts of the poisonous species are dangerous. The seeds are most toxic, then the pods and leaves in that order.

Control will be most profitable on infestations where sheep are unloaded for trailing and must be moved along rapidly.

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W. C. Robocker and Karl G. Parker

MULE-EAR (Wyethia amplexicaulis Nutt. and W. helianthoides Nutt.)

Distribution and Description

Mule-ear, also known as green dock and black sunflower, is a tufted perennial with smooth, waxy leaves and a thick taproot. It reproduces only by seed, yet is aggressive and highly competitive.

Mule-ear is common throughout most of the mountainous and foothill areas of the Western United States and occurs in dense stands. It is most common on open flats, parks, broad ridges, and gentle slopes.

Chemical

Esters of 2,4-D or 2,4,5-T.

Rate, Volume, and Carrier

Good results have been obtained with 2 lb. acid equivalent per acre of 2,4-D in 10 gallons water applied by ground rig, or in 3 gallons diesel oil applied by air. The ethyl, butyl, and butoxyethanol esters of 2,4-D have been used successfully.

Good results can be obtained with 1 lb. 2,4-D or 2,4,5-T esters; however, several applications may be needed at this rate to kill these weeds (*2*).

Time of Application

Results are best in immediate prebloom to half-bloom stage.

General Considerations

Ranges should be rested from grazing for at least two seasons following spraying. High volatile esters will be more effective than the low volatiles or salts on dry range sites; however, extreme caution should be exercised when spraying with esters near sensitive crops.

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Claire E. Letson

PLANTAIN LEAF BUTTERCUP (Ranunculus alismaefolius Geyer)

Description and Occurrence

Plantain leaf buttercup and other species of buttercup are widely distributed on mountain meadows and other moist grazing areas in the Western States (*1*). Low palatability and low forage yields make buttercup undesirable on ranges used by domestic livestock.

Chemicals and Treatment for Control

Two pounds of the alkanolamine salt of 2,4-D in 9½ gallons of water and ½ gallon of diesel oil per acre have given excellent results in control (*2*). In Oregon, buttercups have been controlled with 1 to 1½ lb. of an amine of 2,4-D, and tolerant legumes such as white clover recovered without necessity of reseeding (*3*).

Time of Application

Spraying in late-bloom stage gives better kill than earlier spraying (*2*).

General Considerations

Buttercups are susceptible to the ester forms of 2,4-D. Although kill was less than with the alkanolamine salt, the butyl ester form might be feasible if spraying is carried out in conjunction with treatment of sagebrush on nearby areas. If buttercup control is the main goal, then the alkanolamine salt would have an advantage because it is less volatile, less expensive, less likely to injure legumes, and more effective. MCPA has been successfully used in England for buttercup control (*4*).

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Donald R. Cornelius

SNAKEWEED, BROOMWEED (Gutierrezia sarothrae [Pursh] Britt. & Rusby and/or *G. microcephala* [DC.] Gray)

Description and Distribution

Broom snakeweed (*Gutierrezia sarothrae*) and threadleaf snakeweed (*G. microcephala*) are closely related, low, compact, short-lived perennial half-shrubs up to 2 feet tall with a woody base and slender, alternate, entire leaves. The two species often resemble each other, especially in areas where they grow together. Some authorities consider *G. microcephala* a variety of *G. sarothrae*. These weeds are widely distributed from Texas to California, north to Colo-

rado and Idaho, and south into Mexico. They aggressively invade disturbed areas and are often an indication of overgrazing. They are poisonous to livestock, especially when the leaves are forming (*3*). Though usually not eaten they may be browsed in early spring and late fall when no other green plants may be available.

Herbicides for Control

Applications of 2,4-D, 2,4,5-T, silvex, or MCPA all reportedly effect fair or good snakeweed control (*1, 4, 5, 6, 7*). Threadleaf snakeweed seems a little more sensitive to these herbicides than broom snakeweed (*4*).

Rate, Volume, and Carrier

Treatment with 1 to 2 lb. ae./a. of 2,4-D, 2,4,5-T, or silvex effects fair to excellent control (*1, 2, 5, 6, 7*). Ester formulations seem best. Ground applications at 15 to 20 g.p.a. seem adequate; aircraft application may be made at 5 g.p.a. (*1, 2, 5*). Diesel oil, water, or an emulsion of oil and water are all satisfactory carriers (*1, 2, 5, 6*). Diesel oil may give earlier top kill, but lower plant kills (*7*). Adjuvants have not been consistent in improving results (*7*).

Timing

Timing is critical in controlling snakeweed with herbicides (*2, 5*). Best results are obtained when growing conditions are optimum. The initial leaves should be fully expanded, the new twig growth 3 to 5 inches long, and the flower buds not evident. Soil moisture should be medium to high. In the southern part of snakeweed's range this may be as early as mid-April; further north it may be as late as mid-July.

General Considerations

Applications at other than the optimum time will either not damage the plants or only kill tops. Retreatment may be necessary to kill new seedlings and partially killed plants. Proper grazing management is necessary for control because a good grass cover retards snakeweed invasion.

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Thomas N. Johnsen, Jr.

ORANGE SNEEZEWEED (Helenium hoopesii Gray)

Distribution and Description

Orange sneezeweed is a perennial herbaceous weed of the aster family. Flower heads are sunflowerlike, up to 3 inches across, solitary or several on long, often woolly stalks, with orange-yellow ray flowers. Altitudinal range is 5,000 to 12,000 feet from eastern Oregon to western Montana and south to New Mexico and California. This plant can cause serious sheep losses during the late summer or early fall after other vegetation is dry and in short supply.

Chemical

Ester of 2,4-D, silvex (2,4,5-TP), or 2,4,5-T.

Rate, Volume, and Carrier

Four lb. acid equivalent of 2,4-D per acre has given 85 to 95 percent control. This should be applied in water at 30 to 40 g.p.a. All parts of the plant should be covered. Two to three lb. ae./a. of 2,4,5-T or silvex will control associated broad-leaved perennial forbs better than the 4 lb. of 2,4-D.

Time of Application

Spraying should be done in the prebloom stage. Flower buds should be forming and plants growing rapidly.

General Considerations

Control will be short-lived unless a good perennial cover can be established. Areas on which sneezeweed has been controlled should be rested from grazing during the year of control or until the residual perennial vegetation has improved enough to prevent reinvasion. Followup treatments may be required.

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William A. Worf
Revised by: Donald F. Hervey

LEAFY SPURGE (Euphorbia esula L.)

Distribution and Description

Leafy spurge is a noxious, perennial, herbaceous field weed believed introduced from southern Russia into southwestern Minnesota with oats in 1890 (*4*). Known as early as the year 1000, when it was designated as wolf's milk, it is still known by this name in many localities of Europe (*3*).

The plant is a long lived, deeply rooted herb 8 inches to 3 feet tall with simple or clustered stems topped by a many-rayed umbel. The leaves lack petioles and are bluish green, turning brownish orange in late summer. Leaves, stems, and roots exude a milky juice when injured. The flowers are small and greenish yellow. The plant responds readily to soil moisture; under extremely dry conditions it often ceases to grow and does not blossom (*3*).

Chemicals

Ester of 2,4-D
Ester of 2,4-D and ammate
Chlorate-borate mixtures
2,3,6-TBA
Borates
Sodium chlorate

Rate, Volume, and Carrier

Six lb. acid equivalent of an ester of 2,4-D in 20 gallons of water, applied twice a year for 3 or 4 years, will provide up to 98 percent kill.

Complete kills have been obtained with 4 lb. acid equivalent of 2,4-D ester and 100 lb. ammate per acre followed by application of 4 lb. 2,4-D per acre the following spring.

Borate-chlorate mixtures at the rate of 15 lb. per square rod gave 100 percent kill by the end of the third year. Heavier applications did not hasten the period of control.

Agricultural borax at 30 lb. per square rod or sodium chlorate at 6 lb. per square rod resulted in 98 and 87 percent kill respectively when applied for 3 years.

Soil treatments of 2,3,6-TBA of 20 lb. acid equivalent per acre may be applied in spring or fall.

Trichlorobenzoic/boron mixture is an effective spot treatment when applied at 1½ lb. per square rod in spring or fall. Many grasses will tolerate this treatment.

Time of Application

2,4-D should be applied during the early bud to bloom stage. Treatment after seed pods form is ineffective. Soil sterilants may be applied in spring or fall.

General Considerations

Do not graze for 1 year after treating with 2,3,6-TBA. Leafy spurge is relatively tolerant to light applications of 2,4-D. But a combination of 2,4-D and cultivation is effective. Cultivate every 2 or 3 weeks until early August and then spray with 2 lb. 2,4-D per acre.

A season of intensive cultivations, followed by a fall-seeded grass crop, which in turn is sprayed in spring and fall with 2 lb. 2,4-D per acre, will eliminate 95 percent or more of the stand.

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Claire E. Letson

ST. JOHNSWORT, GOATWEED, OR KLAMATH WEED (Hypericum perforatum L.)

Description and Occurrence

St. Johnswort is an aggressive weed introduced from Europe. By 1949 it had invaded over 2 million acres in California alone, and other Western States also had extensive infestations (*3*). It crowds out desirable range forage plants when once established and is also somewhat poisonous to livestock.

The plant is a perennial, grows in dense patches, and spreads by both seeds and rootstocks. It reaches 15 to 25 inches in height and has yellow, five-petaled flowers with petals that have many black dots around the edges. Leaves are oblong, opposite, and have small pinhole-like glands that appear to be transparent when held up to the light.

Chemicals

The chemicals most commonly used for control are proprietary forms of borax or 2,4-D. Borax preparations are used on small infestations, and 2,4-D on larger infestations and scattered stands.

Rate, Volume, and Carrier

Borax is applied at 4 to 8 lb. per square rod, either broadcast or drilled into the soil. 2,4-D is applied at a minimum rate of 2 to 3 lb./a. The carrier may be water at 10 g.p.a. or more or 3 g.p.a. of oil.

Time of Application

Borax can be applied in spring. Treated stands should be marked and followup checks made to insure that all plants are killed. 2,4-D is applied in early summer, when plants are 6 inches tall, to early bud stage. Resistance to 2,4-D increases as the plant matures (*3*).

General Considerations

Leaf-feeding beetles of the genus *Chrysolina* and a root borer were released in the United States in 1945 to parasitize St. Johnswort (*3*). The acreage now infested in California is about 1 percent of that before the beetles were introduced. But an increase has been noted in some areas (*4*) and particularly in Northern States where local environment affects the life cycle of the beetles. St. Johnswort may show a cyclic increase and decrease as a result of the host-predator relationship.

Scattered stands may be controlled by grazing sheep when the plant is putting up its terminal growth and again in early summer. Range in good or excellent condition is less likely to be invaded. Proper grazing following the decline of St. Johnswort from chemical or biological control measures will help prevent an increase in other undesirable weeds.

St. Johnswort is no longer considered among the top 10 weeds in economic importance in the Western United States, and it is not listed among the 10 weeds of secondary importance (*1*). Apparently little or no work has been done in the past 10 years on control with herbicides.

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W. C. Robocker

TALL LARKSPUR (Delphinium occidentale [Wats.] Wats.)

Description and Occurrence

Tall larkspur is a large showy plant closely resembling the domesticated delphinium of the garden. It grows 2 to 6 feet tall. The bluish-purple flowers emerge

during July in most places. Tall larkspur is found in "stringer" valleys, open parks, and in aspen groves in the spruce-fir zone. It is common on summer range in the mountains of Montana, and south to Colorado and Nevada. Tall larkspur is one of the chief causes of cattle losses on national forest ranges.

Chemicals for Control

Silvex (2,4,5-TP) and 2,4,5-T are about equally effective in control. An oil soluble amine form of 2,4,5-T (marketed as Emulsamine) has been particularly effective in Colorado tests because it reduced the undesirable forbs and left many desirable ones. In Idaho the propylene glycol butyl ether ester form of 2,4,5-T provided outstanding control. Silvex reduces the total ground cover slightly more than 2,4,5-T; both herbicides bring about rapid increase in the percent of grass.

Rate, Volume, and Carrier

Research indicates that for ground application with ordinary spray systems 3 to 4 lb. ae of the herbicide in water at 30 to 40 g.p.a. should be applied to wet the entire larkspur plant to drip stage. For ground application with a mist-blower, use 3 to 4 lb. ae of the herbicide in water at 10 g.p.a. and cover the area at least twice with the mist. No results of aerial applications are available; helicopter applications of the usual 3 to 4 lb. ae/a. of the herbicide would be valuable experiments.

Time of Application

Tall larkspur can be controlled with herbicides only if spraying is done in the prebud stage, results becoming progressively poorer in bud and flower stages. Spray dates will be during June, the exact dates depending on elevation and year.

Control of 80 to 100 percent can be achieved under ideal conditions. Followup spraying has sometimes proved successful when initial control was unsatisfactory. Good results have been obtained most consistently under aspen stands; poorest results in dry, open parks.

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Donald F. Hervey

TANSY RAGWORT
(Senecio jacobaea L.)

Distribution and Description

Tansy ragwort was introduced from Europe. First reported from the Northeastern United States and the Province of Quebec, it has since been reported from Vancouver Island and British Columbia to northern California. There is no published record for the North Central States, indicating that it may have had a double introduction, one in the East and the other in the West. Leaves are 2 to 8 inches long and finely divided. The yellow flower heads are ½ to ¾ inch wide.

Chemicals

Tansy ragwort can be controlled if it is treated in the proper stage. Hughes (5) reports an 80 percent kill using the amine of 2,4-D. Furtick and Chilcote (2) report that the butoxyethanol ester of 2,4-D was the most effective chemical tested.

Rate of Application, Volume, and Carrier

Furtick and Chilcote (2) reported 2 lb. 2,4-D per 100 gallons of carrier was effective in control. Hughes had good success with 1.5 lb. of the amine in 40 gallons of water per acre. Little work has been done with carriers for the control of this species.

Time of Application

Treatments were effective only at the rosette or bolt stages. Later treatments were not effective with any chemical.

General Considerations

This weed is apparently spreading rapidly and becoming a cause for concern, especially in the Pacific Northwest. It particularly invades pastures, wet places, and cultivated ground. In addition to its competitive characteristics it is also poisonous. It has a potentially greater geographic distribution, and we will no doubt be hearing much more about it.

Interest in chemical control seems to have lagged with discovery of a possible biological control. The cinnabar moth (*Tyria jacobaeae* L.), released in recent

years to control the plant in the West, has become established in California and has also been recovered in Oregon (*4*). Establishment north of Oregon is still a question, and reliance on herbicides may still be required.

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W. C. Robocker and Fred Tschirley

CLUSTER TARWEED (Madia glomerata Hook.)

Distribution and Description

Cluster tarweed is a herbaceous annual of the Compositae family that attains a height of 4 to 20 inches. In the intermountain area it most commonly occurs in openings from 6,000 to 10,000 feet. It is a heavy invader of overgrazed mountain ranges that frequently have high potential. Tarweed seed germinates early in the spring (occasionally under snowbanks) and grows vigorously, maturing in late summer. It is distributed from Saskatchewan to Colorado and California and introduced eastward.

Chemicals

Esters, amines, or sodium salts of 2,4-D.

Rate, Volume, and Carrier

Amines or esters of 2,4-D should be applied at ½ to 1 lb. acid in 30 gallons of water per acre. It is important to wet the plant thoroughly.

If the sodium salt of 2,4-D is used, 1 lb. in 30 gallons of water per acre should be applied.

Time of Application

Spraying should be done before the tarweed plants reach the four-leaf stage of growth. Reduced kills result when plants are sprayed in the 6- to 10-leaf stage of growth.

General Considerations

Soil cultivation after foliage leaves develop, but before seed begins to form, will also kill tarweed.

Adapted grasses should be planted before or immediately following tarweed kills to prevent reinvasion.

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William A. Worf

CANADA THISTLE (Cirsium arvense Scop.)

Description and Occurrence

Canada thistle was introduced into the United States and Canada during the Revolutionary War. This perennial weed is widespread throughout the Northern United States, extending south into California and Virginia. Although considered of primary impor-

tance on cereal grain land, it now occurs on many types of farming, grazing, and forested areas.

Canada thistle grows from 2 to 4 feet in height. Plants are dioecious. Reproduction is from both seeds and roots. Ten ecotypes have been recently distinguished in the Western States by Hodgson (*7*). Differences noted include leaf ruffling, spininess, and seed size. Flower color varies from pale blue to purple and white. A 3-week range of maximum emergencies in the spring was noted, and most important from a control standpoint, differences in response to cultivation and herbicides were discovered.

Chemicals for Control

A wide range of herbicides have been tested for effect on Canada thistle; these include amitrole, phenoxy compounds, sodium, chlorate, fenac, 2,3,6-TBA, dicamba, and picloram. Despite apparent better kills obtained with other herbicides, 2,4-D is recommended for large infestations; amitrole, 2,3,6-TBA, and dicamba are recommended for spot infestations. In preliminary experiments excellent control has been obtained with picloram. However, it should not be used on grazing land until registered for such use.

Rate, Volume, and Carrier

2,4-D is recommended for treating large infestations of Canada thistle in rights-of-way, small grain fields, ditchbanks, and pastures. For other than cultivated fields, it should be applied at 2 to 4 lb./a. in water at 20 g.p.a. (*2*). MCPA is usually equal to 2,4-D in controlling Canada thistle (*2–5*).

Many herbicides are more effective than 2,4-D and are practical for eradicating patches of Canada thistle, but they are more costly. Amitrole is applied at 4 to 6 lb./a. in water at 20 g.p.a. (*6*). 2,3,6-TBA at 10 to 20 lb./a. is practical on small areas, and dicamba at 5 lb./a. has given almost complete control (*1*). Some ecotypes or environmental conditions may require 10 lb./a. of dicamba for complete control (*1, 8*). Although it is rather soon to make recommendations for this herbicide, picloram has been effective at one-fourth to 2 lb./a. (*9*). For general recommendations, rates higher than the minimum will probably be required. Do not use it on grazing land until it is registered for such use.

Time of Application

First application of 2,4-D is usually in the early bud stage of growth. Followup treatment can be made in 3 to 4 weeks, after new growth appears (*6*). Treat with amitrole at bud to early bloom stage. Plants should not be mowed, but they may be plowed 3 weeks after spraying (*2, 6*). Dicamba and 2,3,6-TBA should be applied at full bloom (*7*). Picloram is very effective when applied at early bloom (*9*).

General Considerations

If possible, Canada thistle should be controlled by spot treatment in an early stage of invasion. Large amounts of chemicals and time will be required in treating and retreating if this perennial is allowed to spread over an extensive acreage. Abandoned and denuded lands are most likely to be infested. Repeated cultivation at 3- to 4-inch depth every 21 days will give elimination in one to one and one-half seasons (*3, 8*).

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W. C. Robocker

WATERHEMLOCK (Cicuta spp.)

Description and Occurrence

Waterhemlock is a native perennial which reproduces both by seeds and fleshy roots. It grows in marshy ground and along streams where rich loamy soils accumulate, and also near the waterline of irrigation delivery and drainage channels. *Circuta douglasii* is the common species of the western range States, while *C. maculata* is common in the Eastern States. About eight species of waterhemlock are known in the United States, and some of these are also known in Canada. Waterhemlock is rare or absent in the Great Plains States.

The stems of waterhemlock are erect, branching, and hollow. Leaflets are distinguished by the peculiar manner in which the veins in the leaflets run to the notches on the edge of the leaflet rather than to the tips. When cut longitudinally, the rootstock shows a number of transverse chambers which contain the toxic substance. Waterhemlock has the characteristic appearance of the parsley family.

Chemicals

The ester form of 2,4-D is the most practical chemical for controlling waterhemlock. 2,4,5-T is also effective. Soil sterilants are generally impractical because of the excessive moisture of the plant sites.

Rate of Application, Volume, and Carrier

2,4-D at 2 lb./a. can be applied in water at 10 g.p.a. A greater volume of water can be used if necessary to obtain adequate coverage.

Time of Application

For satisfactory kills, herbicide should be applied in early growth up to the early bud stage.

General Considerations

Waterhemlock is considered the most poisonous plant of the United States. Caution should be taken to keep livestock from sprayed areas. 2,4-D tends to increase palatability of waterhemlock. Plants normally ignored by cattle grazing in the pasture are more readily grazed after spraying and may cause serious losses. The plant is not effectively controlled by burning and mowing.

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W. C. Robocker

WILD IRIS
(Iris missouriensis Nutt.)

Description and Distribution

Wild iris, Rocky Mountain iris, or western blue flag is a native iris which grows in wet meadows and along streams from North Dakota to New Mexico and west to the Pacific coast from southern California to British Columbia (*5*). It is a perennial herb and appear to spread chiefly by rootstocks. Seed is abundantly produced, although data on germination are not available. Its pale blue to almost white flowers are borne on stalks 6 to 40 inches in height and are conspicuously visible in overgrazed pastures and ranges where soil moisture is high. It is worthless as a forage plant and competes for moisture and nutrients with more desirable species.

Chemicals

Both the volatile and low-volatile esters of 2,4-D (*1–4*) have been satisfactory for wild iris control, although Thornton found the low-volatile ester caused some injury to grass.

Rate of Application, Volume, and Carrier

Two to 4 lb./a. of an ester of 2,4-D in oil or water or in an oil-water emulsion, at a volume of carrier adequate to secure satisfactory coverage, is recommended. Volumes of 3 to 100 g.p.a. have been used with success.

Time of Application

Herbicide may be applied during the bud stage of development (*3*) or at early flowering (*1*). Cords (*2*) obtained best control in Nevada by applying 4 lb./a. of 2,4-D just after blooming.

General Considerations

Despite the scarcity of published data on wild iris control, the effectiveness of the controls recommended above was quite definite. Thornton (*4*) and Cords (*2*) tried other chemicals as well as 2,4-D, and although they found dalapon to be effective, it was as harmful to grass as to wild iris. Thornton also found 2,4,5-T and a mixture of 2,4-D and 2,4,5-T were less effective than 2,4-D alone and that both also injured grass.

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W. C. Robocker

WOODY PLANTS

CHAMISE
(Adenostoma fasciculatum H.&A.)

Description and Occurrence

This evergreen shrub grows on mountain slopes and ridges at 500 to 5,000 feet. It occurs throughout the foothills of the Sierra Nevada and Coast Range in California (*1*). The plant is upright and coarse, 2 to 10 feet in height or taller. Chamise is an excellent example of a fire type. It has strong reproductive power in sprouting from numerous dormant buds at the base of stems and in germination of seed following fire to give dense stands of seedlings. Mature chamise is one of the most unpalatable shrubs in California for domestic livestock. New sprouts are eaten as browse by sheep and deer.

Chemicals for Control

No chemical spray has been satisfactory for killing mature plants. The practical procedure is to remove old growth by burning or by mechanical means and to spray the sprouts and seedlings with 2,4-D or a mixture of 2,4-D and 2,4,5-T.

Rate, Volume, and Carrier

Chamise control should be started after a fire by seeding burned areas with grass. Regrowth can be controlled by spraying with ground equipment the first or second year after a fire. A brush-killer mixture of 2,4-D and 2,4,5-T at 4 lb. ae./a. is suggested by Leonard and Harvey (*3*), but 4 lb. of 2,4-D ester per acre usually gives a comparable kill. Under unfavorable conditions more than 4 lb. of herbicide per acre increased the kill. Plumb and Bentley (*4*) report that 5.2 lb. acid equivalent of low-volatile ester of 2,4-D in 26 gallons water-oil emulsion per acre gave adequate kill. Lower rates of chemical, 2.6 lb., in a lower volume of emulsion, 13 gal./a., was too light for satisfactory kill of large, vigorous chamise sprouts. Doubling the amount of chemical (5.2 lb. in 13 gallons) was more effective than keeping the chemical at 2.6 lb. and doubling the volume of emulsion. Leonard and Harvey (*3*) state that chamise regrowth can be controlled by aircraft spraying during the first spring after fire, using the same herbicides as above and a spray volume of 5 gal./a. For individual plant treatment by hand spray, a brush-killer mixture of 2,4-D and 2,4,5-T, at 4 lb. aehg water plus 1 gallon diesel oil is recommended (*3*).

Time of Application

Chamise plants are most readily killed with 2,4-D by spraying the young sprouts in the spring after a fall burn. Many plants were not killed when sprayed before all of the potential sprouting portions of the burl had developed sprouts (*1*). Delaying the spraying until after the soil moisture was greatly reduced also resulted in a poor kill. Thorough coverage of the sprouts is needed to insure a good kill. Adequate coverage seems difficult after the sprouts are 6 inches (or more) in length. This timing with sprout development usually permits most seedlings to have emerged and to be sprayed at a susceptible stage along with the sprouts.

However, delayed germination may occur as much as a year after the burn, so followup treatment with broadcast spraying is required. If only spot treatment is required for sprouts, followup treatment may be done with a hand sprayer.

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Donald R. Cornelius

CHOLLA CACTI (Opuntia spp.)

Description and Distribution

The round-stemmed species of *Opuntia* are known as cholla or cane cactus. Some species have become so abundant on some southern Arizona and New Mexico ranges that they provide a barrier to movement and grazing of livestock. Cholla are most commonly found on dry sites below 3,800 feet. Their habit varies from low-growing, spreading plants to tall, arborescent forms.

Herbicides for Control

At present no herbicides are available as broadcast treatments for an economic control of cholla. Control is limited to relatively small areas for individual plant treatments. Several herbicides are in use: Silvex 2,4,5-T, TCA, DNBP, and dichlorprop; all give adequate control (*1, 3, 6, 7, 8*). A new herbicide, picloram, reportedly effective on pricklypear (2), has been effective in very limited tests on whipple cholla (*Opuntia whipplei* Engelm. & Bigel.) in northern Arizona (*4*). Picloram is not registered for use on rangelands; DNBP requires a long waiting period before grazing.

Rate, Volume, and Carrier

High concentration and high-volume applications are necessary for adequate control. Eight to 10 lb. aehg of an ester of silvex or 2,4,5-T is recommended; 12 lb. aehg of DNPB in water also is suggested (*8*). One-half to three-fourths lb. of TCA per gallon of water gives good control (*6, 7, 8*). Henry (*3*) reports that 2 lb. aehg of 2,4,5-T or silvex is effective in New Mexico. Garcia and Hickey (*1*) used 5 to 16 lb. aehg for dichlorprop. Picloram seems effective at 2 lb. aehg in water (*2, 4*). One gallon of spray used to treat individual plants should cover 14 to 20 plants (*1*).

Time of Application

July and August are best for application of silvex or 2,4,5-T (*7, 8*). DNBP and TCA can be effectively used over a wider period, but applications should not be made during extremely dry seasons (*6*). The quickest response to dichlorprop was obtained with applications made just as new growth began (May) rather than 30 days later. However, plant kill was the same (*1*).

General Considerations

Picloram has not been registered for use on grazing lands; therefore, it should not be used except experimentally until a label for such use has been approved. Further trials are needed with picloram to determine if it is effective when broadcast. All available herbicides are limited to treatment of relatively small areas by individual plant applications.

A mist blower may speed applications, and seems as effective as standard spray equipment (*1, 4*). Even with complete control, the many dead joints lying on the ground would prevent proper utilization of forage species by livestock. This is especially true of jumping cholla (*Opuntia fulgida* Engelm.). Since about 40 percent of the cholla may be killed by fire (*5*), it seems that fire may become a valuable tool. Fire and herbicides may be used in combination to remove dead joints.

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Thomas N. Johnsen, Jr.

CREOSOTEBUSH
(Larrea tridentata [DC.] Coville)

Description and Occurrence

Creosotebush, a member of the caltrops family, is a common evergreen shrub, usually 3 to 6 feet tall. It occurs on an estimated 46½ million acres in the arid Southwest from California to western Texas. It spreads from seed. This plant is worthless for browsing. Desirable perennial grasses cannot compete with creosotebush. After creosotebush becomes established on a site, it can gain dominance rather rapidly. When this occurs, the entire site deteriorates from wind and water erosion.

Chemicals

(TCA) granules, fenuron-TCA granules, and trichloro-

Individual plant treatment with fenuron pellets have consistently given plant kills in excess of 90 percent. Monuron powder, monuron-trichloroacetate benzoic acid granules have been less effective.

Rate

An effective rate is an individual plant treatment of 1 gram active ingredient of 25 percent fenuron pellets (1 level teaspoon = 1 gram active ingredient) for each 1½ feet of canopy diameter. The pellets should be scattered around the base of the plant.

Time of Application

Since fenuron is desensitized by light and high temperatures, it is important that the materials be applied just prior to, or in the early part of, an expected rainy season.

General Considerations

This is an economical method of controlling sparse stands (up to 75 plants per acre) of creosotebush. It would be especially beneficial where creosotebush is invading grassland. The work reported was done on gravelly sandy loams in southern New Mexico.

Carlton H. Herbel

COMMON GALLBERRY
(Ilex glabra [L.] Gray)

Description and Occurrence

Common gallberry, a member of the holly family, is an evergreen shrub, usually 2 to 5 feet tall, that occurs frequently in low pinelands, swamps, and prairies near the coast from Louisiana to Massachusetts. It spreads by both seed and rhizomes and is most abundant in southern Georgia and in Florida.

Chemicals for Control

Foliage spray of a low-volatile ester of 2,4,5-T was effective in studies by Burton and Hughes (*1*) and Smith (*2*).

Smith (*2*) got excellent kills with 2,4,5-T in oil sprayed on stems and rootcollars and on stumps, but the costs were greater than spraying foliage with the chemical in water.

Rate, Volume, and Carrier

Two pounds acid equivalent in 50 gallons of water or oil per acre was sufficient for foliage sprays in Georgia (*1*). Water is the preferred carrier in the summer, but oil is more effective for fall sprayings. In Mississippi, 4 lb. acid equivalent in 19 gallons of diesel fuel was very effective when sprayed in August on stems and rootcollars, but more than 55 gallons of spray was required per acre (*2*).

Time of Application

For foliage sprays, August is best with water as the carrier, and November is best with oil as the carrier. Stem and rootcollar and stump treatments are effective in August. Applications in other months have not been tried.

General Considerations

Common gallberry is worthless for cattle, is a physical barrier to good forest land management, increases the hazard and intensity of forest fires, and competes with desirable forage and trees. However, the species isn't worthless. It is a good source of honey. Also the fruit is eaten by several game birds including quail and wild turkey, and the leaves are eaten by marsh rabbit.

Longtime residents of southern Georgia and northern Florida frequently comment on the apparent increase of this plant. Unless its spread is curtailed, forest land management costs will increase, and forage and timber yields will decrease.

Periodic burning of critical areas is the control method generally employed by landowners. This method temporarily eliminates top growth. Resprouting following the burn is profuse, and stems may become more numerous. Burning of gallberry in March increases the effectiveness of August sprayings.

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Lowell K. Halls

GREASEWOOD (Sarcobatus vermiculatus Torr.)

Distribution and Description

Greasewood is a spiny shrub that is common on saline soils in many Western States. It is a valuable browse for livestock in the fall and winter if it is eaten with other forage. However, the oxalate in young stems and fresh leaves has poisoned sheep. Justification for and interest in greasewood control is largely lacking, and detailed studies have not been reported.

Chemicals

Data are not available for citation, but considerable confidence has been expressed in the effectiveness of 2,4-D esters or amine.

Rate, Volume, and Carrier

Apply 2,4-D esters or amine at 2 lb./a. Carrier and spray volume are not specified.

Time of Application

Spray when greasewood is growing rapidly. If interest in control arises, timing of application should be investigated because prolific sprouting after spraying has been observed.

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D. N. Hyder

JUNIPERS (Juniperus spp.)

Description and Distribution

In the Western States junipers are shrubby, coniferous trees with appressed scalelike leaves. Junipers are characteristic of the pinyon-juniper woodlands, which occur at intermediate elevations above the desert, grassland, or chaparral types and below the ponderosa pine type. Various species of juniper may be found growing in most of the Western States. Invasion of grazing lands and the resultant loss of forage are probably most serious in Arizona, New Mexico, and Texas. There the most important problem species are as follows: Alligator juniper (*Juniperus deppeana* Steud.), Ashe juniper (*J. ashei* Buchholz), one-seed juniper (*J. monosperma* (Englm.) Sarg.), Pinchot juniper (*J. pinchotii* Sudw.), and Utah juniper (*J. osteosperma* (Torr.) Little). Of these, one-seed and Utah junipers are the most widespread and probably the most important problem species. Alligator and Pinchot junipers are sprouting species and difficult to kill.

Herbicides for Control

Numerous herbicides are effective for controlling junipers treated individually. Effective herbicides applied to the foliage and stems include the following: Arsenite (*8*); AMS (*3, 13*); esters of 2,4-D and 2,4,5-T (*7*); and PBA (*9, 4*). Effective herbicides applied to the soil surface around the tree base include pelleted fenuron (*1, 5*); and granulated TBA (*2, 5*). A new herbicide, picloram, has shown promise either as spray or pelleted applications in limited tests (*11, 12, 6*) but it cannot be recommended until it has been registered for such use. Arsenite should not be used on grazing land; grazing should be deferred for 1 year after treating with TBA.

No herbicide has yet been recommended for broadcast applications to control juniper. Only a few experimental broadcast herbicide applications have been tried on junipers, and results have been variable; 2,4,5-T and 2,4-D have given poor results (*10*); PBA has given poor to fair results with Utah juniper (*6*).

Rate, Volume, and Carrier

For effective control junipers treated individually with sprays require thorough coverage. Rates of 8 to 16 lb. aehg applied to the drip point are needed with 2,4-D, 2,4,5-T, and PBA. An oil carrier may give quicker results, but water has often been equally effective. PBA must be applied in oil. Pelleted fenuron and granulated TBA have been effective when applied at about 1 tablespoon of material per 3 feet of tree height. Trees over 12 feet have responded variably to soil applications of fenuron and TBA. Pelleted fenuron applied at 4 lb./a. has controlled junipers effectively but with higher rates needed on finer textured soils (*1*). Picloram is effective when applied to the foliage at 1 lb. aehg as a wetting spray (*11*) or at 7.5 lb./a. as pellets (*12*), but it cannot be recommended until it has been registered as a control.

Time of Application

Early spring or late fall appear to be best for foliage applications. These should be made when the tree is growing actively and while soil moisture is medium or high (*7*). Applications to the soil seem effective at any time of the year; they do require adequate precipitation to leach the herbicide into the root zone.

General Considerations

Because arsenic is toxic to man and animals, it should not be used. A mistblower may reduce labor and herbicide costs when individual trees are treated with sprays. Soil texture, organic matter and the like affect those herbicides that are applied to the soil; these factors must be considered. Broadcast application of fenuron may reduce or eliminate all ground vegetation for one or more years.

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Thomas N. Johnsen, Jr.

MANZANITA (Arctostaphylos spp.)

Description and Distribution

Manzanitas are evergreen shrubs with leathery, entire margined, upright, alternate leaves. The stems are crooked and rigid with a thin, smooth, shiny, dark red or chocolate-colored bark. These shrubs are distributed throughout the Western United States, but they are especially abundant in the chaparral zones of Arizona, California, and Oregon. They are frequently the first woody plants to invade burned or cutover areas.

Herbicides for Control

The esters of 2,4-D are usually equal to or better than those of 2,4,5-T (*2, 4, 7, 8*). In California, 2,4,5-T

is recommended for use in fall for release of pine (*9*). In limited tests a new herbicide, picloram, has given good plant kills of greenleaf manzanita (*Arctostaphylos patula* Greene) (*3*), but it is not registered for use on grazing land. In limited trials in Arizona good kills of pointleaf manzanita (*A. pungens* H.B.K.) were obtained with picloram and pelleted fenuron (*6*).

Rate, Volume, and Carrier

One to 2 lb. aehg of esters of 2,4-D or 2,4,5-T in water applied to the drip point are effective (*2, 4, 7*). Aerial applications of 3 lb./a. of an ester of 2,4-D at a volume of 5 to 10 g.p.a. are recommended (*5, 7*). With the sprouting species, treatments may have to be repeated for 3 years to obtain good control (*5*). Generally, an oil-in-water emulsion has shown little advantage over a water carrier. If an emulsion is recommended, it will usually contain 5 percent diesel oil. Good results were obtained with picloram applied at 1 lb. aehg in water to the drip point (*3*), but it cannot be recommended until it has been registered for use on rangeland.

Time of Application

Most efficient control is obtained during active growth, with treatments in July slightly better than those at other times (*2, 4, 5, 7, 9*).

General Considerations

Picloram has not been approved for use on rangelands. The nonsprouting manzanitas are relatively easy to control with herbicides. However, the sprouting species, such as *Arctostaphylos patula* Greene and *A. glandulosa* Eastw., may require repeated applications for satisfactory plant kill. Where manzanita is controlled to release suppressed ponderosa pine (*Pinus ponderosa* Laws.), the pine may be injured by the herbicide (*2, 9*). The lower rates cause the least damage, and 2,4,5-T does less damage than 2,4-D (*2*). Spring or fall applications damaged pine, and also the manzanita, least.

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Thomas N. Johnsen, Jr.

MESQUITE
(Prosopis juliflora [Sw.] DC.)

Description and Distribution

Three varieties of mesquite occur in the United States (*1*). Velvet mesquite (*Prosopis juliflora* var. *velutina* [Woot.] Sarg.) is found principally in Arizona; honey mesquite (*P. juliflora* var. *glandulosa* [Torr.] Cockerell) is found in Texas and New Mexico; and western honey mesquite (*P. juliflora* var. *torreyana* L. Benson) is found principally in southwestern New Mexico, southeastern and western Arizona, and California. Velvet and honey mesquite are of most importance, and the following discussion is limited to them.

Velvet mesquite is a tree up to 45 feet tall. Primary leaflets are in one or two pairs; secondary leaflets in 14–30 pairs; each leaflet oblong, 7–13 mm. long and 2–4 mm. wide. Honey mesquite is a shrub or small tree 9–25 or 30 feet tall. Primary leaflets are in one or rarely two pairs; secondary leaflets in 6–13 pairs; each leaflet linear or narrowly linear-lanceolate, 24–63 mm. long and 2–4 or rarely 6 mm. wide.

Chemicals for Control

The low-volatile esters of 2,4,5-T are recommended for foliage applications on both honey and velvet mesquite. High-volatile esters, while effective, should not be used where there is any possibility of damaging susceptible crops. Soil treatments using monuron have been effective when applied around a trunk base. Basal stem treatments using diesel oil or diesel oil fortified with esters of 2,4,5-T are successful on single or several stemmed trees, but the method is too laborious for multiple-stemmed trees.

Rate, Volume, and Carrier

The recommendation for controlling honey mesquite in Texas by aerial application varies with the type of mesquite being treated. For tree-type honey mesquite, ½ lb. 2,4,5-T in 1 gallon diesel oil and enough water to make 4 gallons of solution per acre is recommended. For running-type honey mesquite, ⅔ lb. 2,4,5-T in 1 gallon diesel oil and enough water to make 5 gallons of solution per acre is recommended (*4*).

Velvet mesquite in Arizona can be controlled by aerial application using ⅓ lb. of 2,4,5-T in an emulsion of 1 part diesel oil and 7 parts of water. Total volume of the spray solution should be 4 g.p.a. Two treatments are necessary. The second treatment may be made the following year or after an interval of 1 or 2 years depending on the degree and speed of refoliation after the initial treatment (*9*).

Foliage treatments by ground spray application have been used principally on honey mesquite in New Mexico. The recommendation for control is 1¼ lb. low-volatile ester of 2,4,5-T in 100 gallons of water applied as a wetting spray (*10*).

Monuron is the most effective of the substituted urea herbicides for individual tree treatments. Monuron can be applied as the 80 percent wettable powder, 25 percent pellets, or as the wettable powder in a water suspension. Higher kills are obtained when the water suspension is poured around the base of the plant, but costs are higher than when using pellets or wettable powder alone. One gram of active ingredient per foot of crown diameter is recommended for plants whose crown diameter does not exceed 6 feet. Dosage should be increased for larger plants (*2, 5*).

Diesel oil applied to stems about 8 inches above ground line is the most economical method for controlling scattered stands of velvet mesquite (*7*). Sufficient oil (about 1 pint) should be used so that it runs down the stem and comes in contact with the dormant buds at the root-crown transition zone. The cost of this method is about 5 cents per tree. Eight lb. of an ester of 2,4,5-T per 100 gallons of diesel oil is recommended for basal treatments on honey mesquite (*2*).

Time of Application

Foliage treatments to honey mesquite should be made 40 to 90 days after first leaf emergence (*2*) and when conditions for growth are favorable. The critical period for velvet mesquite is when the leaves have reached full size but are still succulent, flower development is complete, and terminal twig elongation has stopped. This period usually occurs in May, 40 to 60 days after first leaf emergence.

Soil treatments with monuron should be made shortly before a rainy season so that the material is carried into the soil where it can be absorbed by the roots. The herbicide is inactivated by light so prolonged exposure on the soil surface reduces its effectiveness.

Basal stem treatments with diesel oil or fortified diesel oil can be made at any time of the year.

General Considerations

Aerial applications to honey mesquite result in excellent top kill, but root kill may vary from 5 to 95 percent. Where root kills of 30 to 50 percent are obtained, sprout growth is rarely large enough to permit retreatment within 4 to 7 years. Where kills above 50 percent are obtained, retreatment at intervals of 8 to 10 years can be expected to give good to excellent control of honey mesquite. Aerial applications to velvet mesquite result only in defoliation, and a retreatment must usually be made 1 or 2 years after the first treatment.

Research in Arizona has shown that about 50 percent of the perennial grass forage is lost when there are 25 mesquite trees per acre (*8*). Consequently, the greatest return per dollar invested is obtained by individual plant treatments in areas of scattered stands.

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Fred H. Tschirley

MESQUITE
(Prosopis juliflora [Sw.] DC.)

(This is supplemental information on mesquite.)

Chemicals

On sandy soils in southern New Mexico and western Texas, individual plant treatments with fenuron pellets and monuron powder have consistently given high plant skills. Fenuron-trichloroacetate (TCA), monuron-TCA, and trichlorobenzoic acid are less effective.

Rate

Effective on sandy soils is an individual plant treatment of 1 gram of active ingredient of fenuron pellets or monuron powder for each foot of canopy diameter. The materials should be well scattered around the base of the plant.

Time of Application

Since these materials are desensitized by light and high temperatures, it is important that the materials be applied just prior to, or in the early part of, an expected rainy season.

General Considerations

This method is economical in controlling sparse stands (up to 75 plants per acre) of mesquite on sandy soils in southern New Mexico and western Texas.

Carlton H. Herbel

BLUE OAK
(Quercus douglasii H.&A.)

Description and Occurrence

Blue oak occurs over several million acres of woodland-grass rangeland in California. The trees are 20 to 60 feet high and thrive on dry or rocky foothills of the Sierra Nevada and inner Coast Range. An excessive number of trees on a range unit reduces production and utilization of forage. Forage produced beneath the trees is less palatable to livestock than that produced on similar areas without trees. Cattle consuming large quantities of acorns may undergo impairment of health. Blue oak density or combination with brush and other trees may cover so much of the range that handling the livestock is difficult, and the grazable acreage is too low. A few scattered blue oaks may be advisable for shade in summer and for promoting growth of early winter forage by protecting annual understory plants. Basal sprouts usually appear when trees are cut.

Chemicals for Control

Foliage sprays have not given as satisfactory results as cut-surface treatment of the tree trunks. Amines of 2,4-D and 2,4,5-T were both effective and about equal when applied to cuts in the trunk. The ester of 2,4,5-T was appreciably more effective than 2,4-D (*1*). The amine of 2,4-D should be used, as it is cheaper and produces as good a kill as the other chemicals (*1*).

Rate, Volume, and Carrier

The amine of 2,4-D can be best applied undiluted, 4 lb. of acid equivalent per gallon. Cuts should be made horizontally by a hatchet or ax and spaced every 4 inches around the trees. Cuts should penetrate through the bark and into the sapwood. The chemical must be applied to the sapwood if good kills are to result (*1*). Cuts made near the ground are more effective than those higher on the trunk.

The amine of 2,4-D is applied by means of a pump oilcan. Experiments with rate of application showed that 4 milliliters per cut was the optimum amount for best kill of blue oak. One gallon of chemical should be adequate to treat 300 trees 1 foot in diameter (*1*).

Hand equipment that combines the operation for making the cut and applying the chemical has now become commercially available. A hollow-pointed probe is jammed through the bark into the sapwood. A valve release mechanism can then be turned to let the desired amount of chemical flow through the hollow tube to the tip into the cut.

Time of Application

Blue oak is most susceptible to kill by the cut-surface method in winter and spring. Sensitivity increases markedly between August 8 and November 4 (*1*). Trees reach a high point in sensitivity in November when there is a complete absence of growth in the tree tops, approximately 1.5 inches of rain falls and air temperatures become lower, thus decreasing transpiration. Roots probably start growing about this time. Top kill occurs more rapidly when trees are treated just prior to the appearance of new leaves in the spring. Fall applications show no visible effect until the following spring when growth starts (*1*).

General Considerations

A control burn will usually be needed from 3 to 5 years after chemical treatment of blue oak to clear out the dead and fallen debris. An increase in palatability of forage under treated trees has been observed the first season after treatment.

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Donald R. Cornelius

POST OAK (Quercus stellata Wangenh.) and BLACKJACK OAK (Q. marilandica Muenchh.)

Description and Occurrence

Post oak (*Quercus stellata* Wangenh.) and blackjack oak (*Q. Marilandica* Muenchh.) are commonly associated. Post oak is distributed from Cape Cod west through central Ohio, south to Iowa, south to central Texas, and to northern Florida. Blackjack oak is widely distributed and occurs rather abundantly in certain areas of the following States: New York, New Jersey, Pennsylvania, Ohio, Michigan, Illinois, Iowa, Kansas, Oklahoma, Texas, and Florida.

These two oaks have little to no grazing or commercial value. They form dense stands on areas heavily grazed, or where desirable hardwoods have been removed. Especially in Texas, these undesirable woody species have increased on approximately 18 million acres of rangelands. These oaks require considerable water, and compete effectively with forage species for soil moisture.

Methods of Control

Mechanical.—Such methods as bulldozing, anchor chaining, and girdling of large trees have given various degrees of success. Brush and weed cutters, as well as root plows, have been useful in controlling oak saplings. However, under such treatments goats should be allowed to graze, to control sprouts that arise following such treatments.

Chemical.—These oaks can be controlled with two or more aerial applications of 2,4,5-T or silvex (2,4,5-trichloropropionic acid) esters. Recommended treatments are esters of 2,4,5-T or silvex at 2 lb. per acre (acid equivalent basis), initially followed by an additional 1½ to 2 lb. of 2,4,5-T or 1 to 2 lb. of silvex during the first or second subsequent growing season. Aerial applications are made as 1:4 oil/water emulsions at a volume of 5 gallons per acre. Black oak is less susceptible than post oak to these chemicals, and 2,4,5-T should be used when other weed tree species are present.

Post and blackjack oaks can also be controlled in individual plant treatments by spraying the foilage, spraying the stem with ester in diesel oil from ground level up to 12 to 14 inches, by injecting the solution directly into the plant through the bark, or into the soil at the tree base. Foilage sprays containing 2 to 3 ahg (acid equivalent per 100 gallons) of an ester of 2,4,5-T or silvex should be applied as a drenching spray. Spraying the trunk base with a solution of 12 to 16 lb. ahg of 2,4,5-T in diesel oil is effective on trees with stems not greater than 5 or 6 inches in

diameter. Silvex should not be sprayed on the trunk base.

Various herbicides such as 2,4,5-T, silvex, and ammonium sulfamate may be injected directly into the plant by utilizing freshly cut surfaces, such as frills or stumps, near the ground. Frills consist of a band of overlapping, downward ax cuts, completely circling the trunk. Better kills are obtained by treating frills and stumps cut near ground level. Particular attention should be paid to treating the cambium and outer bark surface of stumps. Oil solutions containing 12 to 16 aehg of 2,4,5-T or silvex are effective. Ammonium sulfamate can be applied as crystals or in water solutions containing not less than 3 lb. of ammonium sulfamate per gallon.

Injection of oil solutions containing 8 ahg of 2,4,5-T into the soil at the base of trees is an effective treatment. An inexpensive soil fumigating gun is used for making the treatments.

The knapsack hand sprayer is an effective tool for applying a herbicide mixture to individual trees, using the trunk base, frill, or cut-stump methods.

Time of Application

Foliage sprays are restricted to the period of active growth after the leaves become full sized. Trunk-base sprays may be most effective when applied during winter dormancy, but are effective at all seasons. Cut-surface treatments are used generally the entire year. Soil injections should be made only during early spring and the period of maximum plant activity.

Experimentally, substituted phenyl ureas are used to a limited extent by broadcasting in granular form over the soil surface. Blackjack and post oaks are equally susceptible, but some other associated woody plants are not so sensitive.

Before any of these treatments are applied, more complete information should be obtained from the publications listed below or from other informed sources.

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Hurlon C. Ray

SHRUB OAK (Quercus turbinella Greene and/or *Q. dumosa* Nutt.)

Description and Distribution

Quercus turbinella and *Q. dumosa* are closely related oaks. Ranging from shrubs to small trees up to 15 feet, these species have small, hard evergreen leaves and are similar in shape. They sprout from the root crown if the stems are damaged. Their classification varies considerably. Some authors consider them to be distinct species; others regard them as varieties or forms of one species or the other (*8*). They are characteristic of the chaparral type and often form dense thickets. *Q. dumosa* occurs mainly in California; *Q. turbinella* occurs widely but is most prevalent in central Arizona. Their ranges overlap in southern California where they intergrade.

Herbicides for Control

Broadcast or spot applications of pelleted fenuron or monuron will control shrub live oak (*2, 10*). Repeated foliage applications of esters of 2,4,5-T or silvex kills top growth but few plants (*3, 7, 6*). Encouraging results were obtained in Arizona from limited tests of picloram, a new herbicide not yet registered for use on grazing lands (*1*).

Rate, Volume, and Carrier

Pelleted fenuron or monuron, applied at the rates of 4 to 16 lb. ai/a., is an effective control (*2, 10*). The lower rates are effective on coarse-textured soils, and the higher rates on fine-textured soils. Spray applications of an ester of 2,4,5-T or silvex prove best at 4 lb. ae/a. applied at 20 g.p.a., either with 5 percent diesel oil or a surfactant added to the carrier (*3*). Appli-

cation of these two herbicides is also effective at 4 to 8 lb. aehg as a wetting spray with 2 percent diesel oil on first-year sprouts (*6*).

Timing

Fenuron applications obtain good results regardless of season of treatment. Foliage sprays of 2,4,5-T or silvex applied in May to fully expanded new leaves kills top growth most quickly. However, regrowth is less vigorous after fall treatments (*4*).

General Considerations

Fenuron and monuron need moisture to move them into the root zone before they become effective. These herbicides may kill the understory vegetation, leaving a bare soil for a year or more after treatment. Monuron seems more destructive of such vegetation than fenuron (*2*). Do not graze cattle for 90 days after application of fenuron. Uniform coverage by spray materials is difficult to obtain on shrub oak (*9*), so that the resultant control may be spotty.

In a controlled burning program, desiccation of the foliage with 2,4-D may help to reduce the danger of a controlled burn's becoming a wildfire by allowing burning during relatively low fire-hazard periods. (*5*).

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Thomas N. Johnsen, Jr.

SHINNERY OAK
(Quercus havardii Rydb.)

Description and Occurrence

Shinnery oak, a member of the beech family, is a small shrub and thicket-forming. It grows in sandy soil, spreads by underground stems, and the larger part of individual plants is underground. Propagation is by separation of the rootstocks, as well as by acorns. Shinnery oak occurs in the southern Great Plains and in the Southwest.

The large, sweet acorns are relished by livestock, but this species has caused much poisoning. The plant acts as a physical barrier to good range management, and competes with desirable forage plants (*1*).

Chemicals for Control

The best control (*2*) obtained was over 90 percent, when shinnery oak had been sprayed 2 or 3 consecutive years with 2,4,5-T low-volatile ester, silvex low-volatile ester, or dichlorprop low-volatile ester. A single properly applied spray treatment usually kills 20 to 30 percent of the shinnery; two successive treatments in consecutive or alternate years usually kill 50 to 70 percent; and three treatments 90 to 99 percent.

Rate, Volume, and Carrier

Aerial application.—The most efficient treatments have been ½ lb. of acid equivalent to 2,4,5-T, silvex, or dichlorprop in 3 gallons of diesel oil per acre, applied 3 successive years.

An emulsion of 1 gallon of diesel oil and 2 gallons of water is equally as effective as diesel oil alone, but the emulsion requires proper equipment for continuous violent agitation. It also requires managerial vigilance (*3*).

Application of herbicides by airplane is a specialized job. Areas to be sprayed must be flagged, and qualified technical guidance must be secured. A reliable applicator, licensed by the State plant board, should be employed. Airplane spray equipment should be designed for low pressure, to apply a coarse spray that deposits large droplets. The best spraying conditions usually occur late in the evening and early in the morning.

Ground spraying.—Effective treatments have been one-half lb. of 2,4,5-T, silvex, or dichlorprop in 5 gallons of diesel oil or an emulsion of 1 gallon of diesel plus 4 gallons of water per acre, applied 3 successive years.

Time of Application

Applications are effective only between May 15 and June 15. The plant should be growing rapidly during treatment. Spraying of shinnery oak should be postponed if plants are injured by or growth rate is slowed by late frost, hail, insects, hot dry winds, livestock grazing (particularly in spring of second or third spray treatment), drought, temperatures above 90° F., winds above 10 to 15 m.p.h., or when thunderstorms are likely within 1 hour of treatment.

General Considerations

The spray must thoroughly cover the leaves, terminal buds, and all growing stems of the plant. The air temperature should be moderate, with high relative humidity, and wind velocity not exceeding 10 m.p.h. Spot treatment with ground equipment may be necessary in the fourth year to secure complete eradication (*2*).

Grass production can be doubled for a period of 3 to 5 years by spraying shinnery only once with ½ lb. of 2,4,5-T, silvex, or 2,4-DP; but only 20 to 30 percent of the brush is killed (*2*).

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Hurlon C. Ray

PINYONS (Pinus edulis Engelm., *P. monophylla* Torr. & Frem., *P. cembroides* Zucc.)

Description and Distribution

Pinyons are widely distributed shrubby pine trees characteristic of pinyon-juniper woodland and parts of the sagebrush deserts. Pure stands often grow at higher elevations. In old stands trees may be 35 feet tall and also numerous. In dense stands there is often little or no understory vegetation.

Herbicides for Control

Information available on effects of herbicides is scarce and mostly incidental to juniper and sagebrush control studies or derived from work with other pine species. Pines are generally resistant to foliage sprays of 2,4-D, 2,4,5-T, silvex, and PBA (*1, 2, 6, 7*). Ammonium sulfamate seems effective either as a foliage spray or as a frill treatment (*2, 4*). Pelleted fenuron applied to the soil around the base of the tree has killed *P. edulis* (*5*).

Rate, Volume, and Carrier

Pelleted fenuron at the rate of one tbsp. per 3 feet of height is effective on small trees on loam soils (*5*). Frill application of ammate, at concentrations of 2–4 ai./gal. of water, or 1–2 tbsp. crystals in each notch or frill, has been effective on other pines (*2, 4*).

Timing

Best timing of treatments remains to be determined. For other species, this is generally during optimum growing conditions.

General Considerations

Because ammonium sulfamate is corrosive, spray equipment should be cleaned immediately after use. Frill treatments are best for larger trees, cutting for smaller ones. Do not graze areas treated with fenuron for 90 days after application. Pinyons are often valuable for nuts (*3*) and for Christmas trees. Christmas tree sales may be an efficient and economical control measure.

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Thomas N. Johnsen, Jr.

PRICKLYPEAR (Opuntia platyopuntia)

Description and Occurrence

Several species of pricklypear are associated under "*Opuntia platyopuntia.*" The name "*platyopuntia*" refers to the flat-jointed species that are adapted to rather large grassland areas of the central and southern Great Plains in the United States. They vary in size from the rather low-growing central plains plants to huge plants common to some areas of south Texas. The two principal methods of controlling or eradicating pricklypear on rangelands are grubbing and chemical treatments.

Chemical Methods of Control

Chemicals normally used for control include the 2,4,5-T esters, mixtures of 2,4-D and 2,4,5-T esters, silvex, sodium trichloroacetate (TCA), and dinitro compounds in diesel oil, in kerosene, or in emulsions of water and oil in various ratios. The chemicals effectively control all forms of most pricklypear, provided all parts are thoroughly covered.

The chemical 2,4,5-T is commonly used in the treatment of *Opuntia platyopuntia* species in the Southwest and certain adjacent areas. Since the sale of this herbicide is regulated by law in certain States, one should become familiar with where and how it may be used.

Rates, Volume, and Carrier

Solutions of 2,4,5-T are usually explained in a descriptive writeup attached to the containers in which they are sold. Eight lb. of active ingredient per 100 gallons of diesel oil have been most effective for controlling Engelmann and Nopal pricklypear in the Southwest. But stronger solutions may be necessary in certain other locations.

Hand application of 2,4,5-T solutions with knapsack, compression tank-type, and power sprayers have been most effective. Pressures of 25 to 35 lb. for hand sprayers and 40 lb. for power sprayers are recommended. Large-sized droplets are more desirable for covering pricklypear plants than are small or foglike droplets. Both sides of the pricklypear pads, joints, and fibrous trunks must be wet thoroughly, to the point of slight runoff, for effective kill and control. Diesel oil or kerosene should be used with hand sprayers, while oil-water emulsion can be used in power sprayers equipped with agitators. Emulsion sprays are as effective as oil sprays if they are kept agitated, but more volume of solution is required for treating individual plants. The use of emulsion will reduce the cost of treating pricklypear on large areas. Boom-type sprayers have not been as satisfactory as have the methods cited above.

Time of Application

The hot summer months are usually the most desirable time to spray.

General Considerations

Grubbing and piling of pricklypear is practical on many rangelands, and is usually done on contract for $4 to $9.50 per acre, depending on species and density. The piles are often burned when work is slack.

Good range management is the key to preventing reinfestation of treated range. Otherwise the above treatments do not pay, as shown by reliable trials in the Southwest.

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Hurlon G. Ray

RABBITBRUSH (Chrysothamnus viscidiflorus Nutt., C. nauseosus Britt.)

Distribution and Description

Chrysothamnus viscidiflorus and *C. nauseosus* are extremely variable in appearance as each includes about 20 varieties. Generally *C. viscidiflorus* has green herbage and *C. nauseosus* has gray herbage; thus, they are often known by the common names green rabbitbrush and gray rabbitbrush. They are small to medium shrubs of the open plains and foothills up to 10,000 feet. These shrubs are most abundant in the Great Basin where they appear on a variety of sites from salt meadows to dry upland sites with sandy soils. Green rabbitbrush is rated as fair forage for sheep and big game animals, but gray rabbitbrush is seldom grazed.

Chemicals

A number of herbicides have been tried, but successful control has been obtained only with 2,4-D esters.

Rate, Volume, and Carrier

Apply 2,4-D ester at 3 lb./a. in water with wetting agent (or other carriers if preferred) at a total spray volume as low as 5 gal./a.

Time of Application

Spray after new twig growth exceeds 3 inches in length and when large bunchgrasses (i.e., *Agropyron spicatum*) are heading out. Earlier applications kill the active growing tissues but allow lateral and basal sprouting. Effectiveness drops as soil moisture is depleted in the surface 10 inches and the herbage of Sandberg bluegrass (*Poa secunda*) is losing green color.

These spraying requirements may also be used to kill rabbitbrush and big sagebrush in mixed stands. *Chrysathamnus nauseosus* is more susceptible to 2,4-D than *C. viscidiflorus* and might be killed adequately with as little as 2 lb./a.

General Considerations

Root planing, burning, and plowing (in decreasing order of effectiveness) have been used to control rabbitbrush. *Chrysathamnus nauseosus* is quite susceptible to burning in the spring. The sprouts of either species that appear after burning are sensitive to 2,4-D.

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D. N. Hyder

COLORADO RUBBERWEED (Hymenoxys richardsoni Hook.)

Species, Description, and Distribution

Colorado rubberweed, often called "bitterweed" or "pingue," is a member of the composite family and resembles bitterweed (*Hymenoxys odorata*) in many respects. It is a perennial herb with tufted stems, is 1–5 dm. high, branched above, and glabrous, or nearly so. Leaves are alternate, mostly basal, divided into 3 to 5 narrow lobes, and glandular dotted. The plant is woolly at the base, with dense, cottony hairs between the lower leaf axils. The numerous heads are 1 to 2 cm. in diameter and are arranged in flat-topped clusters similar to those of *Hymenoxys odorata*. Colorado rubberweed is long-flowering, and blossoms from the last of June to about the end of August. Some of the mature seed heads remain until late fall. The plant contains small amounts of intracellular latex.

Distribution and Habitat

Colorado rubberweed grows mostly in grasslands and open forests on dry, sandy, or gravelly soils from Saskatchewan on the north to the borders of Texas and west to California, Utah, and Oregon. It ranges upward from 5,000 feet and is found at 10,000 feet in certain areas. While it has been reported to kill sheep in Texas, close botanical identification shows the deaths to be due to bitterweed mistaken for Colorado rubberweed. It extends eastward only to the western border of Texas.

Chemical Control

Herbicides have been used with varying success. While Parker reports a 95.3-percent kill with a 25-percent aqueous solution of atlacide applied as a spray, this treatment would be too expensive under range conditions. But certain investigators have obtained the best kills to date with esters of 2,4-D. Water solutions of concentration of 2 to 4 lb. per acre, applied as wetting sprays, or spray of 1½ lb. of acid equivalent of 2,4-D in 25 to 50 gallons of water per acre, applied with power equipment, are recommended. More research with various chemicals is needed.

Time of Application

Spray should be applied as soon as the first leaves are approaching normal size and flowers are beginning to develop. Little or no results are apparently obtained from spraying after the flowering stage.

General Considerations

Animals poisoned.—Sheep may be killed by Colorado rubberweed poisoning any time during the year. But it is most dangerous in early spring and late fall on ranges of little desirable forage.

Poisonous nature and symptoms.—Symptoms are similar to those of bitterweed (*Hymenoxys odorata*). Sheep that have eaten considerable Colorado rubberweed are usually distinguished by a typical green discoloration about the mouth and nose, and loss of appetite. They walk with difficulty, and with arched backs. Severe cases show frequent caughing and sneezing that results in a green mucous secretion from the nose and mouth.

Control and management.—There is no medical cure for severely poisoned animals; therefore, as soon as animals show symptoms of poisoning, they should be removed to clean or desirable pastures or be put on feed. Range in good condition will aid in controlling Colorado rubberweed.

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Hurlon C. Ray

MEDITERRANEAN SAGE (Salvia aethiopis L.)

Distribution and Description

Mediterranean sage is an exotic biennial plant supposedly introduced from North Africa. In 1948 it had occupied about 50,000 acres of depleted range in southeastern Oregon, but was not known elsewhere in North America. Second-year plants have very broad, hairy, basal leaves and widely branched flower stems up to 3 feet tall. Mature flower stems break off and roll before the wind, and this scatters the seed widely. While stands of cheatgrass and filaree have been nearly eliminated by Mediterranean sage, it has moved infrequently into stands of big sagebrush and bunchgrasses. Livestock and game animals apparently never forage on Mediterranean sage.

Chemicals

The herbicides 2,4-D, 2,4,5-T, and MCPA have been applied, but 2,4-D esters have been most effective.

Rate, Volume, and Carrier

Spray with an ester of 2,4-D at 1 to 2 lb./a. in water or other carrier at volumes as low as 10 gal./a.

Time of Application

Spray soon after new seedlings have emerged in the spring in 2 or more consecutive years to eliminate Mediterranean sage. Spraying in 2 or more years is necessary because the large leaves of second-year plants protect some seedlings from the spray and a residual supply of seed in the soil will produce a few new seedlings.

General Considerations

The release obtained on sprayed plots permits a good growth of cheatgrass and filaree, but the establishment of perennial bunchgrasses should be the ultimate objective. Thus, plowing and seeding generally should be recommended where plowing is appropriate; otherwise, spraying and seeding should be recommended.

Reference

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W. A. Sawyer and D. N. Hyder

BIG SAGEBRUSH (Artemisia tridentata Nutt.)

Distribution and Description

Big sagebrush is a large shrub with silvery green leaves, "*tridentata*" referring to the three teeth at the apex of the leaves. It is the most familiar species of *Artemisia*, and probably is the most abundant shrub in Western North America.

Chemicals

Both 2,4-D and 2,4,5-T are effective. In the early part of the growing season 2,4,5-T at 1 lb./a. is as effective as 2,4-D at 2 lb./a. About 6 weeks later, if growing conditions continue favorable, 2,4-D is equally as effective as 2,4,5-T. Spraying with 2,4-D gives cheaper control than with 2,4,5-T. Mixtures of these two herbicides do not increase mortality per unit of cost.

Rate, Volume, and Carrier

Spray with 2,4-D esters at 1½ to 2 lb./a. in water plus wetting agent (or other carrier, if preferred) at a total spray volume as low as 5 gal./a. with 2,4-D at 1½ lb./a. or as low as 3 gal./a. with 2,4-D at 2 lb./a. Every leaf and stem must be killed to make a dead plant; therefore, more material and spray volume is needed for dense, leafy brush than for open stands. Spray stands of young mature sagebrush, as on seeded fields where the sagebrush are 5 to 10 years old, with 2,4-D esters at rates up to 3 lb./a.

Add a wetting agent to water at a rate of 0.1 to 0.5 percent by volume, then add 2,4-D ester and emulsify. In preparing oil-water emulsions, mix the 2,4-D ester in ½ to 1 gallon of diesel oil, then emulsify in water to the desired volume. The optimum spray volume is 5 to 6 gallons per acre with either water, oil-water emulsions, or straight oil, but one can vary volume and 2,4-D rate inversely a little as indicated above.

Time of Application

Big sagebrush is easily killed at any time during active vegetative growth. The effective spraying season begins when the first new leaves are as large as old leaves carried over winter or when Sandberg bluegrass (*Poa secunda*) has heads emerging from the leaf sheaths. Spraying should stop with the depletion of moisture in the surface 10 inches of soil as indicated by the loss of green in the leaves of Sandberg bluegrass.

General Considerations

Spray as recommended for rabbitbrush to obtain simultaneous control of rabbitbrush and big sagebrush. For the selective control of big sagebrush associated with bitterbrush, or for the simultaneous control of big sagebrush and low larkspur, spray at the earliest part of the effective spraying season of big sagebrush.

Do not spray to control big sagebrush where other susceptible plants are of major importance for forage or conservation.

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D. N. Hyder

SILVER SAGEBRUSH (Artemisiacana Pursh.)

Distribution and Description

Silver sagebrush differs from other species in that the most common type has an entire leaf. It usually grows on deep, fertile, moist soils. The sites usually represent high forage-producing potential.

Chemical

Ester of 2,4-D.

Rate, Volume, and Carrier

Two lb. acid equivalent of an ester 2,4-D in diesel oil at 3 gallons of solution per acre has given good top kills when applied by airplane. Resprouting has often occurred, however, and appears to coincide with the earlier spraying.

Two lb. of an ester 2,4-D per acre is recommended. Water or diesel oil are satisfactory carriers. For aerial application, 3 to 5 gallons of diesel oil per acre or 5 to 6 gallons of water or oil-water emulsion per acre are indicated. At least 10 gallons of solution volume should be used with ground application to insure uniform coverage. Proper timing is essential. The butyl ester of 2,4-D has been the form of 2,4-D most widely used.

Time of Application

Spray should be applied when new twig growth is 3 to 4 inches. This usually coincides with the heading out of large bunchgrasses such as bluebunch wheatgrass or crested wheatgrass. If big sagebrush is to be sprayed at the same time, spraying should be done near the end of the effective spraying period for that plant.

General Considerations

Spraying should be followed by 2 to 3 years of complete rest from grazing.

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William A. Worf

FRINGED SAGEWORT (Artemisia frigida Willd.)

Description and Occurrence

This plant is also called estafiata, Arctic sage, and mountain wormwood, and in Canada pasture sagebrush. Other names are fringed sagewort and fringed sagebrush, and are appropriate since the leaves are very finely divided and rather downy. It is a perennial and is adapted widely to the arid and semiarid plains and mountains of the Western United States.

Stems are from 2 to 24 inches high, the composite flower heads are globe-shaped, and are borne on a rather straight, slender stem which is woody at the base and often much branched there. The stems are erect, rather leafy, and densely haired. The plant has a "sagey" fragrance.

Fringed sagewort increases in grasslands grazed by cattle to a point where production of palatable forage is greatly reduced.

Chemicals, Rates, Volume, and Carriers

Experimental work on control of fringed sagewort has been very limited. What little information is available is not quantitative. Incidental to loco con-

trol, applications in Montana of 2,4-D in water and in oil at the rates of 1 to 3 lb. per acre greatly reduced stands of fringed sagewort. These applications were made during the early part of the growing season when white point loco was in the early growth stage. Also incidental to big sagebrush control operations, good control of fringed sagewort was obtained where 2,4-D at 2 lb. per acre in oil and water was applied from an airplane.

General Considerations

Fringed sagewort has been found to be palatable and nutritious to sheep on winter range in Montana. On such range and possibly in other instances, it might be a desirable plant, and control would not be indicated.

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Karl G. Parker

SALTCEDAR (Tamarix Spp.)

Description and Occurrence

Saltcedar ranges from small trees 3 to 5 feet high to large trees 25 to 35 feet high. The young branches are covered by small scalelike leaves. The very small flowers range from whitish yellow to pink and are borne on slender spikes at the ends of branchlets. Saltcedar seeds, very small and feathery, are produced in enormous quantities, with wind the principal agent of transport.

The three species in 10 Western States are *Tamarix pentandra* Pallas, *T. gallica* L., and *T. tetrandra* Pallas. A fourth species, *T. aphylla* (L.) Karst., planted in the Southwest, has not become naturalized. Saltcedar is a problem in Texas, New Mexico, Arizona, California, Nevada, Utah, Colorado, Wyoming, Kansas, Oklahoma. It ranges from sea level to 7,000 feet and flourishes on river flood plains and along irrigation systems. It becomes established in, and spreads on, soils that remain damp during the seed-flying season and young seedling growth.

Chemicals for Control

Esters of silvex and brush killer (2,4-D + 2,4,5-T, 50-50), the two most promising phenoxy herbicides, seem to differ little in effectiveness. Granular dicamba, picloram, and fenuron also show promise, but dicamba and picloram are not registered for use on rangelands.

Rate, Volume, and Carrier

Rates of less than 2 lb. ae./ac. of silvex are ineffective. While effective in Arizona, 4 lb. ae./ac. of silvex is not effective in New Mexico, Oklahoma, and Texas.

Applications of 10 lb. ai./ac. of dicamba, 10 lb. ai./ac. of fenuron, and 20 lb. ai./ac. of picloram acid granules will kill a high percentage of plants.

Recent information on the effect of volume shows that 80 g.p.a. is better than 10 g.p.a. when low rates of herbicide are used. There seems to be little difference among straight diesel oil, water, and oil-water emulsions.

Time of Application

Two years of research in New Mexico have shown that application in mid-May is superior to applications later in the growing season. Spraying with silvex ester is more effective on regrowth than on undisturbed plants, regardless of whether regrowth is from plants burned or mowed.

There is some evidence that saltcedar from both seedlings and regrowth becomes harder to kill as it grows older. The most effective foliage spray treatment at present consists of mowing or burning, then spraying regrowth.

Dormant Applications

Basal spraying with 8 lb. aehg of silvex ester in diesel oil is effective in winter (December–April). Cutting trees and spraying stumps is even more effective. Recent results show that dormant stem spraying with this formulation is the most effective total plant treatment known at present, commonly giving 95 percent control. Lower and higher rates showed the 8 lb. rate to have a distinct advantage.

General Considerations

It becomes increasingly apparent that followup will be necessary to control saltcedar adequately with the foilage spray materials now available. Even though silvex is now much used, a new compound or an additive to increase its effectiveness is needed to reduce the cost of treatment. Oil-soluble amines will help in reducing volatility damage to susceptible crops, and thickened sprays (invert emulsions, etc.) will reduce drift hazard in the absence of any other efficient herbicide.

Root plowing has been effective in some studies but is expensive and destroys the grass cover. Also, since saltcedar sprouts readily from buried stems, root plowing may only replant the stand if moisture is plentiful soon after treatment.

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Eugene E. Hughes

SAW-PALMETTO
(Serenoa repens [Bartr.] Small)

Description and Occurrence

Saw-palmetto, the most common of our native palms (*1*), grows from the Florida Keys to South Carolina and Louisiana. The branching robust stems of this large evergreen shrub are usually horizontal, creeping outward just under or at the surface of the ground. Occasionally short erect stems arise; these often branch and grow to a height of 25 feet. The procumbent stems form a tangled mass, the leaf crowns ascending to form an almost impenetrable thicket. The plant's immense colonial aggregations frequently cover large acreages.

Chemicals for Control

Burton and Hughes (*2*) and Grelen (*3*) got good results with a low-volatile ester of 2,4,5-T. McCaleb et al. (*5*) report 75 percent or better kill with 2,4,5-T (butoxy ethanol ester), dalapon (2,2-dichloropropionic acid), and erbon (2-(2,4,5-trichlorophenoxyl) ethyl 2-dichloropropionate). Dalapon and erbon are not recommended for general use because they also kill herbaceous forage. Where other vegetation is of no concern, these chemicals may be used effectively to eliminate saw-palmetto.

Rate, Volume, and Carrier

Two lb. per acre acid equivalent of 2,4,5-T were sufficient in Georgia (*2*) but 3.5 or 4 lb. were best in Florida (*3, 5*). The rate for dalapon is 20 lb. active ingredients per acre and for erbon, 120 lb. acid equivalent per acre (*5*).

Water appears to be the best carrier for 2,4,5-T and erbon, and a 1:1 ratio of water and oil for dalapon.

For all three chemicals, 50 to 60 gallons of liquid per acre is suggested.

Time of Application

Best results were from August sprayings in Georgia (*2*). Kill increased where plants were burned the previous spring. September–October treatments appear best for central Florida (*5*). But January, March, and April sprayings were best in the sandhills of northwest Florida (*3*).

General Considerations

Saw-palmetto can be eliminated by double chopping (*4*), but the costs are higher than spraying with 2,4,5-T. Though it is of little use to livestock, its fruit is relished by game.

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Lowell K. Halls

TARBUSH (Flourensia cernua DC.)

Description and Occurrence

Tarbush, a member of the composite family (sunflower tribe), is a common deciduous shrub, usually less than 3 feet tall, that grows on an estimated 13,250,000 acres from western Texas to southeastern Arizona. It generally invades on the more productive flood plain sites and spreads from seed. As it gains dominance, forage production is greatly reduced. Tarbush is practically worthless for browsing.

Chemicals

Individual plant treatments with fenuron pellets, monuron powder, fenuron-trichloroacetate (TCA) granules, and monuron-TCA granules have consistently given plant kills in excess of 90 percent. Trichlorobenzoic acid granules have been less effective.

Rate

An effective rate is an individual plant treatment of 2 grams active ingredient of fenuron pellets, monuron powder, fenuron-TCA granules, or monuron-TCA granules. The materials should be scattered around the base of the plant.

Time of Application

Since these materials are desensitized by light and high temperatures, it is important that they be applied just before, or early in an expected rainy season.

General Considerations

This method is economical in controlling sparse stands of tarbush. It would be especially beneficial in areas where tarbush is invading grassland. The work reported was done on a silt loam soil in southern New Mexico.

Carlton H. Herbel

WILLOWS (Salix spp.)

Description and Distribution

Probably no other angiosperms are more commonly associated with water than the willows. Several hundred species are found in the north temperate and subarctic regions. They are generally distributed over the United States wherever there is enough water. Commerically, the willows are of little importance. They can help prevent streambank erosion, however, and have some horticultural use in parks and gardens. They are also browse for big game animals in winter range and to some extent for domestic livestock. However, willows encroach on hay meadows, and where water is short, become a problem. Elsewhere, they are a brush problem and are often controlled in a general brush control program.

Chemicals

An ester of 2,4-D is effective as a foliage spray for both aerial and ground equipment (*1, 2, 4*). For cut surface treatment, an amine salt of 2,4-D (*4*), or a mixture of 2,4-D and 2,4,5-T available as a commercial "brush killer" may be used. For basal treatment, ester formulations of 2,4-D or "brush killer" is recommended (*4*). Early reports of picloram indicate that it is effective on willows, but no recommendations have been made. Picloram has not been approved for use on grazing lands.

Rate of Application, Volume, and Carrier

Foliage spray.—As a treatment for individual plants, 2 to 3 lb. of an ester of 2,4-D per 100 gallons of water or water plus 1 percent oil applied in an amount to wet foliage has been found satisfactory. For aerial application, 2 to 4 lb. of an ester of 2,4-D in 5 to 10 gallons of water or fuel oil is recommended. At the higher gallonage, water plus 2½ percent diesel oil has proven satisfactory.

Basal sprays.—One lb. of ester of 2,4-D or "brush killer" in 6 gallons of diesel oil should be applied near the ground to the point of runoff.

Cut surface.—A "frill" or girdle, made with hatchet or ax cuts around the base of the tree, should be filled with undiluted amine formulation of 2,4-D. Freshly cut stumps can be treated by painting or spraying, to the point of runoff, the cut bark and about 4 inches of the sapwood with 1 lb. of 2,4-D or "brush killer" in 6 gallons of diesel oil.

Time of Application

Foliage spray.—Spring and summer after leaves are fully expanded and when soil moisture is not limiting.

Basal spray.—Any time, but winter and spring are preferred.

Cut surface and stumps.—Effective at all times, but best results are had from November through May.

General Considerations

The reaction of willows to herbicide varies from species to species. Comparison of results by Leonard (*3*) indicated that in most species where a 100-percent top kill was obtained, there was rarely a 100-percent root kill, and retreatment will most likely be necessary in an effective control program.

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W. C. Robocker

YUCCA (Yucca glauca Nutt.)

Description and Occurrence

Yucca, also known as soapweed, beargrass, or Spanish bayonets, is an undesirable perennial on thousands of acres of rangeland in the central and southwestern United States (*2*). The plant grows 1 to 3 feet high and has many long, thick, sharp-pointed leaves with thready margins. The large root system enables it to survive adverse conditions and makes it an aggressive competitor of desirable forage species (*1, 3, 4*).

Chemicals for Control

Research in Nebraska and Texas (*1, 3, 4*) has shown that low-volatile esters of silvex are the most effective and economical herbicide for yucca control. Silvex is superior to esters of 2,4,5-T; 2,4-D is ineffective. But 2,4,5-T in diesel oil has been effective in individual plant treatment.

Rate, Volume, and Carrier

The recommendation for aerial spraying in Texas is ⅔ lb./a. of silvex in a carrier of diesel oil or oil-water emulsions at 4 g.p.a. In Nebraska silvex at 2 lb./a. has been more effective than lower rates from a single application. Diesel oil has generally been the most effective silvex carrier at 5 g.p.a. as compared with water at 2, 5, and 10 g.p.a. and oil-water emulsions at 2 and 5 g.p.a. A mixture of 8 lb. 2,4,5-T in 100 gallons of diesel oil can be used as a wetting spray on the crowns of individual yucca plants.

Time of Application

Available experimental data indicate that yucca may be treated aerially from May 15 to June 30, preferably during the prebloom stage. Individual plant treatment produces best results when applied from June through September.

General Considerations

Effects of silvex application may not become apparent for several months. Some resprouting may occur one or more seasons after treatment. Wait at least two to three complete growing seasons before retreatment.

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